YEAR BOOK

OF THE

American Iron and Steel Institute

1917

MAY MEETING - - - - - - - NEW YORK
OCTOBER MEETING - - - - CINCINNATI

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FOREWORD

This is the seventh Year Book of the American Iron and Steel Institute.

The first Year Book gave the proceedings of the International meeting which began in New York on Friday, October 14, 1910, and was continued in Buffalo, Chicago, Pittsburgh and Washington.

In 1911 the Institute held no general meetings.

The second Year Book gave the proceedings of the two general meetings held in 1912, the May meeting in New York and the October meeting in Pittsburgh.

The third Year Book gave the proceedings of the two general meetings held in 1913, the May meeting in New York and the October meeting in Chicago.

The fourth Year Book gave the proceedings of the two general meetings held in 1914, the May meeting in New York and the October meeting in Birmingham.

The fifth Year Book gave the proceedings of the two general meetings held in 1915, the May meeting in New York and the October meeting in Cleveland.

The sixth Year Book gave the proceedings of the two general meetings held in 1916, the May meeting in New York and the October meeting in St. Louis.

The present volume contains the proceedings of the two general meetings held in 1917, the May meeting in New York and the October meeting in Cincinnati.

James T. McCleary,
Secretary.

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AMERICAN IRON AND STEEL INSTITUTE

TWELFTH GENERAL MEETING

NEW YORK, MAY 25 AND 26, 1917

The Twelfth General Meeting of the American Iron and Steel Institute was held at the Waldorf-Astoria Hotel, New York City, on Friday and Saturday, May 25 and 26, 1917.

Following the usual practice, three sessions were held on Friday, all in the Grand Ball Room. The forenoon and afternoon sessions were devoted entirely to the reading and discussion of papers. The evening session included the annual dinner. As usual, the papers, discussions and addresses covered questions of metallurgy, of business and welfare work.

On Friday the Secretary had a temporary office near the Grand Ball Room, where members registered for the meeting and were provided with identification buttons and with programs.

The papers of Messrs. Rice, Lamont and Mathesius had been printed in advance and were available in pamphlet form in the foyer.

At the noon recess on Friday the members of the Institute were its guests at a buffet luncheon. During this recess, also, the Directors held a Board Meeting.

The attendance was larger than at any other meeting thus far held.

On the next page will be found the program of the Friday sessions, at all of which the President of the Institute, Judge Gary, presided.

FORENOON SESSION, 10:00 A.M.

Address of the President.............................Elbert H. Gary
Chairman, United States Steel Corporation, New York.

Recent Installations of Large Turbo-Generators..........Richard H. Rice
Engineer, General Electric Company, West Lynn, Mass.

Discussion.....................................David S. Jacobus
Advisory Engineer, Babcock & Wilcox Company, New York City.

Discussion..Alex Dow
President, The Detroit Edison Company, Detroit, Mich.

The Manufacture of Steel Castings...................Robert P. Lamont
President, American Steel Foundries, Chicago, Ill.

Discussion....................................R. F. Flintermann
President, Michigan Steel Casting Company, Detroit, Mich.

Discussion.....................................Samuel P. Bush
President, Buckeye Steel Castings Company, Columbus, Ohio.

AFTERNOON SESSION, 2:00 P.M.

Taking Care of Dependents of Absentee Employes Who Enlist for National Service..E. A. S. Clarke
President, Lackawanna Steel Company, New York.

The Relative Merits of Forming Steel by Pressing, Hammering or Rolling, John Lyman Cox
Engineer, Midvale Steel Company, Nicetown, Philadelphia, Pa.

Discussion...................................E. O'Connor Acker
Bethlehem Steel Corporation, South Bethlehem, Pa.

Surgical Discoveries of the War and Their Application to Industrial Accidents. William O'Neil Sherman, M.D.
Chief Surgeon, Carnegie Steel Company, Pittsburgh, Pa.

Discussion.....................................John A. Penton
President, The Penton Publishing Company, Cleveland, Ohio.

Chemical Reactions of Iron Smelting...............Walther Mathesius
Superintendent of Blast Furnaces, Illinois Steel Company, South Chicago, Ill.

Discussion...................................Henry P. Howland
Superintendent, Blast Furnace, Wisconsin Steel Company, South Chicago, Ill.

EVENING SESSION, 7:00 P.M.

Annual Dinner

The Man of the Future.............................George W. Perkins
Director, United States Steel Corporation, New York.

Brief Tribute to James H. Hoyt.........................Willis L. King
Vice-President, Jones & Laughlin Steel Company, Pittsburgh, Pa.

Co-operation and the Mobilization of Public Sentiment....John A. Topping
Chairman, Republic Iron and Steel Company, New York.

Impromptu Remarks in Response to the Call of the President.

ADDRESS OF THE PRESIDENT

ELBERT H. GARY

Chairman, United States Steel Corporation, New York

Gentlemen, I bid you heartiest welcome. The Institute is entitled to congratulations for the great success which it has reached and for the high position which it occupies in the economic world. The country may congratulate itself that it has an institution of this kind, made up of the character of men constituting its membership. Our meetings are growing larger and larger, and more and more interesting. It is true we have in a measure departed from, or at least modified, the original program; for at the time of the organization it was intended to make this pre-eminently a business organization. As a matter of fact, the business part, strictly speaking, has been somewhat subordinated to the scientific part. Still, we have no cause for complaint, no reason to be dissatisfied; nor need we expect that in the long run our original intentions will not be fully carried into practical effect.

In the formal remarks which I shall make, I have made no reference to business conditions. With you I feel that business, strictly speaking, must be more or less disregarded when compared with the greater questions which so materially affect all of us in our personal contemplation of the world's outlook. I think all of you are satisfied that, so far as our industry is concerned, business conditions are extraordinarily good. The demand for our products is great; the prices offered and made by the purchasers of our commodities are larger than they have been for many years; and the prospects for the immediate future, and as far ahead as we can see, are excellent. Naturally all of us are looking forward with much anxiety, for no one can certainly tell what the future may bring forth. Nevertheless, notwithstanding the enormous drains which will be made upon us for war purposes, we should not forget that the moneys are to be expended in this country and are to remain here, and

that we shall probably see larger volumes of cash and cash assets than this country or any other single country has ever before witnessed; and because of these extraordinary conditions we may hope, and perhaps expect, that with fair management on the part of those in authority our business will not, so far as the present year is concerned, and perhaps for a longer period, be materially interfered with. And so, for one, I feel very hopeful of the future. (Applause.)

United States Did Not Seek War

The people of the United States constitute a peace loving nation. They abhor war and would go, have gone, great lengths to avoid it. They are considerate, reasonable and forbearing. They are not envious of their national neighbors. They neither seek nor desire anything that belongs to any other country. If they had an advantage over other nations, in any department of human endeavor, they would not unjustly profit by it. Their ambition is to cultivate good will and friendship and their hope is to avoid enmities. Their consistent purpose and effort have been to occupy an independent position amongst nations, unentangled and uncomplicated with alliances or associations that might interrupt the policy of aiding and never antagonizing others.

These observations are based on history. The record has been written and cannot be changed by any who may impugn the motives or conduct of our people. Such a citizenship, when driven to self-defense by a barbarous despotism is apt to be the most terrible, even though civilized and human in its combativeness. This country is largely made up of men and women, who came here to live in peace and tranquillity, or the descendents of such; they wish to progress and prosper as the result of privileges which the exclusion of war always permits. The great majority, if not the total, of our inhabitants appreciate what our Republic, with its protective institutions and manifold opportunities, means to every citizen; and with noble impulses they will in every emergency rally around and follow the stars and stripes, their emblem of honor, of liberty and of justice.

We did not desire, we persistently and consistently sought to avoid, trouble with Germany and her allies. We had always been the true friends of the Teutons until the ruling powers, for reasons not comprehended by us, forced us into the position of self-defense. We believed, as indeed it was admitted by the invaders, that they were reckless, lawless and cruel in their treatment of their neutral and unoffending neighbors, but as a nation we refrained from interference or even criticism. As human beings we suffered intensely as we learned of the outrages perpetrated upon the innocent victims of force and brutality; and still our nation, not for lack of sympathy, but rather on legal grounds, stood aloof. We were neither indifferent nor selfish, but our President, after full and careful consideration of all the facts and the construction of the rules of international law as determined by the best legal talent, decided he was obligated to remain silent and inactive. For one, I think his conclusions were warranted.

Even after the Central Powers trespassed upon the well established rights of the persons and property of individual American citizens, our Government was patient and unmoved to action, accepting the excuses and promises of the aggressors. As a nation we exercised more restraint than any large and powerful people ever before practiced under provocation so great. Our chief executive indulged the hope for long and weary and suffering days that our entry into the pending war might be avoided. The wish was father to the thought; and this sentiment filled the minds of the majority of the people of the United States.

At last war was forced upon us. The President was compelled to conclude that we were intentionally attacked that the honor and integrity of our country could no longer be maintained unless the gage of battle was accepted; and in this decision he was supported by the whole country. His clear, powerful, convincing and eloquent statement of the case and impeachment of the enemy will stand out in history as one of the greatest official declarations and also as fully justified by the existing facts and circumstances.

A Colossal Undertaking

But we have entered upon a colossal undertaking, justified only by the necessities of the case and on the highest moral grounds. It is doubtful if any of us fully realizes the strength of the enemy, even though we know his grim determination. His numbers, his preparedness, resources, devices, creative ability, methods, protective barriers, means of rapid mobilization and transfer of troops and supplies, are further advanced in effectiveness than any other army or armies have ever been. This concentration and perfection of the utilities of military strength should not be underrated. Years of steady, active and studious, though secret, effort have brought about the creation of a giant, powerful, remorseless, conscienceless; and up to the present this kind of a government, armed to this extent, seems to have an abiding conviction that it can overcome all opposition and sooner or later pursue a war of aggression and conquest.

Right Makes Might vs. Might Makes Right

And yet, the Allies possess an element of strength not appreciated—if it could under any circumstances be understood—by those who are in control of the armies of the Central Powers. The Allies are contending that Right makes Might; their enemies that Might makes Right. We are of the opinion that we possess a weapon that must prove all powerful. With this as the foundation and inspiration of our armies they are better able to utilize all the forces at their command. It will require time, skill, numbers, sacrifices and large sums of money; but nothing that we do not possess in abundance. For the reason that we are right and the enemy is wrong, we shall probably see other nations of strength and importance, now neutral in attitude, join the Allies, if the war shall be protracted. Some or all of the South and Central American republics, China, Spain, Scandinavia, Holland and Switzerland ought to come in and probably will before the Central Powers are allowed to accomplish what they attempt. These countries could not afford to permit their people to become subject to

the dominance of a nation which considers force as the only consideration for aggression and expansion.

With the unprecedented and increasing wealth and the vast resources of the United States she is able to assist materially in providing the financial necessities for equipping multitudes of soldiers from other countries; and if necessary, all these must be mobilized in the defense of a common and righteous cause. And as to equipment, the brains of the Allies, ourselves included, will in time be sufficient to match and over-match the best talent that is possessed by our adversaries after many years of constant thought and study. Among other things it is conceivable that if the Allies had the best and most effective types of aircraft, outnumbering those of the other side five or ten to one, they could obtain and hold control of the air and in this way destroy the productive works, transports of troops and supplies, storage warehouses and other facilities for offensive and defensive warfare of the enemy, and thus materially increase the advantage now held by reason of numbers and resources. We may be sure our experts are giving due consideration to all the possibilities for improved machines and methods.

What We Are Fighting For

What are we fighting for? This question is asked and answered, in one form or another, by millions of people. I give an answer that seems to me to underlie all others: We are fighting to firmly establish and permanently maintain a basis whereby every international question in dispute must be determined in accordance with the principles of justice.

To bring this about, other questions which are obvious must be determined; but if the above mentioned basis is secured everything else necessary will have been or will be disposed of.

All Should Be Willing to Sacrifice

The task which confronts the country is not confined to the army and navy, although they will be entitled to

the larger part of the credit and glory if we succeed. They offer their bodies as a sacrifice, and they must have the undivided, unqualified support of all outside their ranks. The time, money and prayers of all civilians must be given for the soldiers. They bear the brunt; they are the shield for our safety. All of us are fighting in self-defense. This is our land and the flag is ours. The administrators of the country, from President Wilson down, are no more interested than each of us. Life would not be worth living if our flag were to be permanently furled; if our country were subjugated by an alien enemy, especially such a one as we now defend ourselves against.

The pecuniary burdens to be imposed upon us will be very great. We knew in advance such would be the case. We must pay the enormous cost of mobilizing, equipping, supplying and moving our own armies; and we must advance money and provide supplies to our Allies in accordance with their necessities and our resources. We could not decline if we were disposed, for they are now fighting our battles and we are, with them, under the whole burden. We must never falter nor retrace our steps. Wherever or whenever the end is we must press forward with all our strength, might, minds and souls. The more vigorously we proceed within the limits of intelligence, the sooner will the end be reached.

Equitable Distribution of Tax Burdens

Some of us are complaining or criticizing because of the enormous taxes that are likely to be imposed. We are apt to consider ourselves as opposed by the legislative or executive departments of the Government, as if they were partisans, seeking to punish or at least unfairly treat the private individual. We do ourselves an injustice by harboring such thoughts. We can rightfully claim that the burden of taxation be equitably distributed; that all the people, after exempting the necessities of life, shall be compelled to contribute; and that there shall be no waste or extravagance in making expenditures. If possible taxes

ought to be so levied and distributed as to avoid clogging channels of business prosperity. All this we may properly demand. Equitable distribution is fair and reasonable, and it makes all pecuniarily interested in the subject, including both the collection and the expenditure of the taxes levied. Less than this would tend to create classes—the worst thing for any country.

Now is the time to unite the whole country in a common cause. The soldiers are on a level as they ought to be. All others should be on a level. Classes should be obliterated and also politics, localities and religious differences during war times at least. Opportunity should be open to all; governmental burdens should be borne by all. With such an administration of governmental affairs we should be satisfied, however severe the drafts which are made upon us or upon the larger interests which we represent.

I lately spent a few days in Washington, and it was my privilege to meet a number of men who in legislative halls or executive departments are serving their country; and it is certain that all are actuated by the motive to fairly represent and protect the best interests of the country and all the people. Individuals are not influenced by politics. There are and will be differences of opinion concerning the various questions presented, as a matter of course, but these will be adjusted and the legislation finally passed will represent an honest endeavor to do what is proper.

Government is Co-operating With Business

You have heard some criticism concerning the conduct of the Government's business affairs. It has been said that confusion or at least lack of system or co-operation sometimes appears; but it must be remembered that there has been suddenly thrust upon the Government officials an enormous amount of business, extraordinary in volume and character, and the strength and capacity of all are taxed to the utmost and often beyond physical endurance. Besides, rules of law or of departments established to fit other conditions sometimes appear and prevent the exercise

of judgment which would bring better results if more latitude were permitted. Officials in Washington are entitled to credit and praise for their management under existing circumstances, and so far I believe there is no just ground for severe criticism.

And then there is a disposition on the part of Government officials to co-operate with the business men in promoting the welfare of the country. This is what all of us have desired and advocated, and now we will probably have as much opportunity in this direction as we have ever desired. Just what will be the result in all the ramifications of the business involved remains to be seen. To the extent that the Directors of this Institute have been personally connected with these matters they have been well satisfied, except perhaps as to some of the prices in question.

Mr. B. M. Baruch, Chairman, Committee on Raw Materials, Minerals and Metals of the Advisory Commission of the Counsel of National Defense, writing for himself and the Secretary of War, and also representing the Secretary of the Navy, requested your President to act as Chairman and to appoint other members of a Committee on Steel and Steel Products, to co-operate with the Government; whereupon the matter was brought before the Directors of this Institute and such a committee was designated, consisting of the following:

Elbert H. Gary, Chairman
James A. Farrell, Vice-Chairman
James A. Burden
E. A. S. Clarke
Alva C. Dinkey
Willis L. King
Charles M. Schwab
John A. Topping.

The General Committee has already appointed sub-committees as follows, and more are likely to be appointed:*

*Later these subcommittees were extended in number and somewhat changed in personnel, as shown on pages 9 and 10 of this Year Book.

For Ascertaining Capacities and Supervising Allotments of Orders to Manufacturers:

James A. Farrell
E. A. S. Clarke
J. A. Topping
E. H. Gary, Ex-Officio.

On Alloys:

J. A. Farrell
E. A. S. Clarke
A. A. Fowler
E. G. Grace
E. J. Lavino
E. H. Gary, Ex-Officio.

On Iron Ore, Pig Iron and Transportation:

H. G. Dalton
Frank Richards
Harry Coulby
George T. Dyer
W. T. Shepard
A. H. Woodward
Leonard Peckitt
Frank Billings
Amos Mather, Secretary.

On Sheet Steel:

W. S. Horner
Charles Hadley
Walter Carroll.

On Scrap Iron and Steel:

Eli Joseph
Samuel Deutsch
Vernon Phillips
Joseph Michaels.

On Pig Tin:

John Hughes:
E. R. Crawford
Edwin Groves.

On Tin Plate:

J. I. Andrews
E. R. Crawford
E. T. Weir

The committee and the subcommittees meet regularly and are devoting much time to the work involved. They have, with other work, been engaged in mobilizing the resources of the different producers of steel, such as the Government requires for its purposes, and the statistics are in the possession of the Secretary of this Institute.

The Secretary of the Navy submitted a program for 1917 for plates, structural shapes and bars needed for ships, and after considerable negotiation, contracts were closed in behalf of the producers on the basis of $2.90 for plates and $2.50 for structural shapes and bars. We were of the opinion that in view of present costs and other conditions we should receive larger prices, but in the spirit I have referred to the proposition of the Government was accepted. As costs of production are advancing on account of increases in wages, taxes, prices of certain raw materials, etc., it is expected the Government will be willing to increase its purchasing prices accordingly.

Iron and Steel Fraternity Patriotic

The Iron and Steel fraternity, represented by this Institute, will be actuated by the highest conception of patriotic duty with respect to the requirements of the Government. We will cheerfully bear our full share of the load which must be carried until there is realized a complete triumph over the hosts of aggressive, desperate and inhuman autocracy. Personal interests will yield to the necessities of the country we love. (Hearty applause.)

I am proud to feel that the sentiments which have been expressed are unanimously entertained by the gentlemen who have listened—not that such a feeling was unexpected, nevertheless your emphatic approval is just like you, just like this Institute. The Government will be made to feel that is the kind of people that represent this Institute, and that may be considered as one of the most important parts of the great economic administration of the Government in this time of crisis. (Applause.)

On the program I notice informal discussion under the five-minute rule, and I am very glad to pause here to give any one and every one an opportunity to discuss this important question briefly at this time. Time is not important to consider when we are discussing questions of this kind. I am sure there must be some here who would like to say a word on this subject—a few words. Mr. Robert Hobson, President of the Steel Company of Canada, Hamilton, Canada. (Applause.)

Mr. Robert Hobson: Mr. Chairman and Gentlemen: For the last two years, while in attendance at these meetings, I have held myself somewhat in restraint and been very careful not to say anything with regard to the war that might offend the feelings of my brother members of the American Iron and Steel Institute. Today I am most pleased to feel that we are brothers in arms. (Applause.) Canada, with her population of less than eight millions of people, has already sent across over four hundred thousand men. (Applause.) Her casualties to date have been some eighty-eight thousand—that is, killed, wounded and missing. We are now about to put conscription into force and to raise another hundred or hundred and fifty thousand men, and we feel cheered and heartened by the fact that the great American Republic has joined the Allies in defense of freedom and liberty. (Applause.)

President Gary: There are others. We have plenty of time. I would rather go without luncheon and dinner and everything else than not to give every one an opportunity to be heard at this time. There are lots of you who feel

like speaking, and all the rest will be only too glad to hear you. Some of you are too modest to think you ought to be called on; others of you are afraid you cannot do yourselves justice. You are very much mistaken. (Pause.) Then we are over-modest. Every one of you who would like to speak and who would speak if he felt that he could do himself and the subject justice will please stand on his feet. (All the members of the Institute present rose en masse.) That is the kind of men we have, Mr. Hobson. One man said to another, "I wish I had the ability to speak as you speak," and the other man retorted, "I wish I had the ability to think as you think." (Laughter and applause.)

We shall have a paper on Recent Installations of Large Turbo-Generators, by Mr. Richard H. Rice, Engineer, General Electric Company, West Lynn, Mass.

RECENT INSTALLATIONS OF LARGE TURBO-GENERATORS

RICHARD H. RICE
Engineer, General Electric Company, West Lynn, Mass.

In order that the proper relation of the performance and characteristics of recent large turbo-generator installations to other power generating apparatus may be fully understood, it is necessary that the history of the development of turbo-generator units be briefly reviewed, and also that comparisons be instituted between the various types of generating apparatus now available, all of which will be found in what follows.

Commercial utilization of steam turbines in power stations began with the installation of the 5,000 K.W. vertical machines in the station of the Commonwealth Edison Company at Chicago, in the year 1903. (See Fig. 12.) While various builders had been developing turbines before this date, this was the first installation of a unit of considerable size, and it gave a tremendous impetus to the turbine situation, as it turned the minds of those engaged in the development of power stations toward this form of prime mover.

This installation is typical of the boldness with which our central station owners have risked their capital and their business to promote the development of apparatus of the highest efficiency. During the entire period of the turbine development, the central stations have always been receptive to new ideas and willing to purchase apparatus embodying these ideas and without regard to whether or not such ideas had been crystallized into actual apparatus in operation. Without such far-sighted treatment the development of the steam turbine, with the rapidity which has characterized it, would not have been possible. The whole engineering profession owes a great debt of gratitude to these liberal-minded and courageous men.

The first large turbines were made of the vertical type for the reason that this type lent itself to the particular speeds and dimensions adopted, better than any other type. The original large turbines were made of comparatively slow speed in order that the ordinary materials of commerce could be utilized with moderate strains and good conditions of operation, and to match up with existing knowledge in regard to generator design. This vertical type of turbine was of such reasonable cost, as compared with existing apparatus for developing power, and of such good efficiency, that it rapidly displaced all other types of prime mover in power stations to a very considerable extent, because it reduced the cost of constructing stations and also of putting the current on the lines. This made possible a great expansion of central station business.

As soon as the first units had begun to be installed in volume in our power stations, great development took place not only in increasing the size of the unit, but also a considerable improvement in efficiency. It is worthy of notice that the original installation in Chicago required seven boilers to supply steam for a 5,000 K.W. turbine. Later on these turbines were replaced with 12,000 K.W. units and the original seven boilers were found to be sufficient. (See Fig. 13.) The adequacy of these boilers was due partly to improvement in the efficiency of the turbines, and partly to improvement in the furnace and method of operation of the boilers.

The vertical turbine was manufactured in immense quantities during the ten years from 1903 to 1913. During this time, as has been stated, much was done to improve the efficiency of the turbine. It is some indication of this improvement that the 12,000 K.W. units which replaced the original Chicago machines had an efficiency exceeding that of the original units by 40 per cent. At the same time improvements in generator construction, advances in quality of materials obtainable, and continued research led to the use of higher speeds, and in 1913 this progress had gone so far as to lead to production of machines whose efficiency exceeded that of the original Chicago machines by about 65

per cent. The use of higher speeds of rotation forced the abandonment of the vertical type of machine in favor of the horizontal type, which is better adapted for the smaller

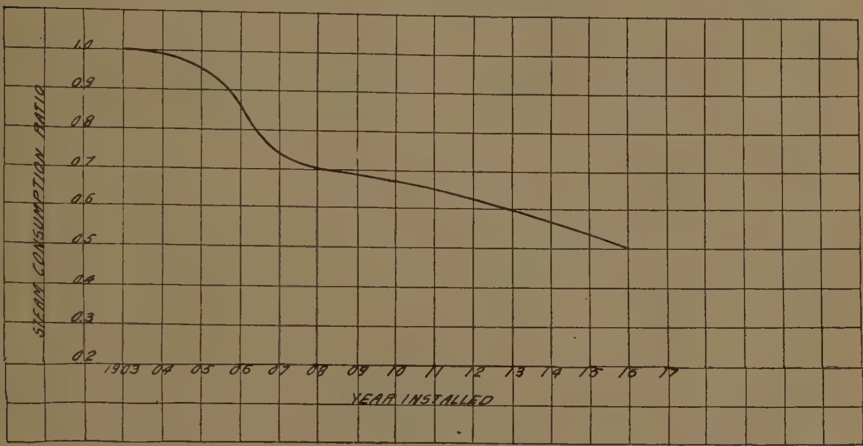


FIG. 1.—Ratio of Steam Consumption in Successive Years to that in 1903, for Largest Size Steam Turbines.

diameters of turbine wheels and generator rotors, which such speeds necessitate. Therefore, from 1913 the development has been confined to the horizontal type. Since that time

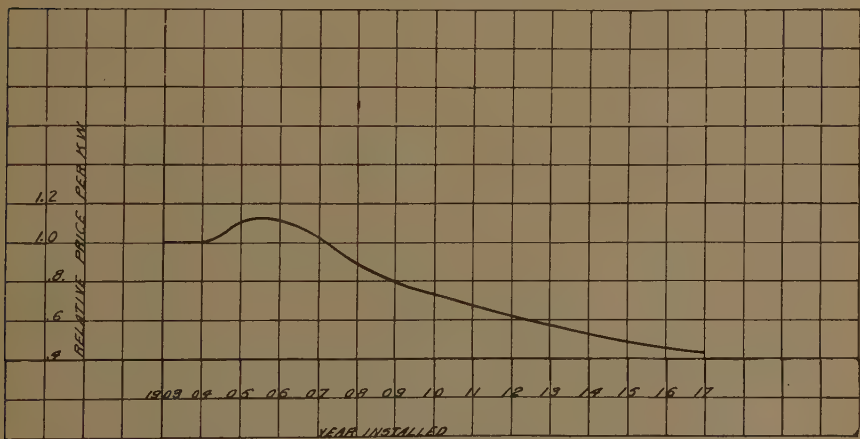


FIG. 2.—Average Price per K.W. of Large Steam Turbines, for Successive Years, in Terms of Price of First 5,000 K.W. Unit.

methods have been found by which the efficiency of turbines has been still further increased by reduction of the

fixed losses. In order to exhibit in a practical way the progress which has been made, curves are given which are based on the performance of the original 5,000 K.W. Chicago machines, first mentioned, and which show very clearly the improvements which have been made in the reduction of steam consumption (Fig. 1), in the price per K.W. (Fig. 2), and in the weight in pounds per K.W. (Fig. 3).

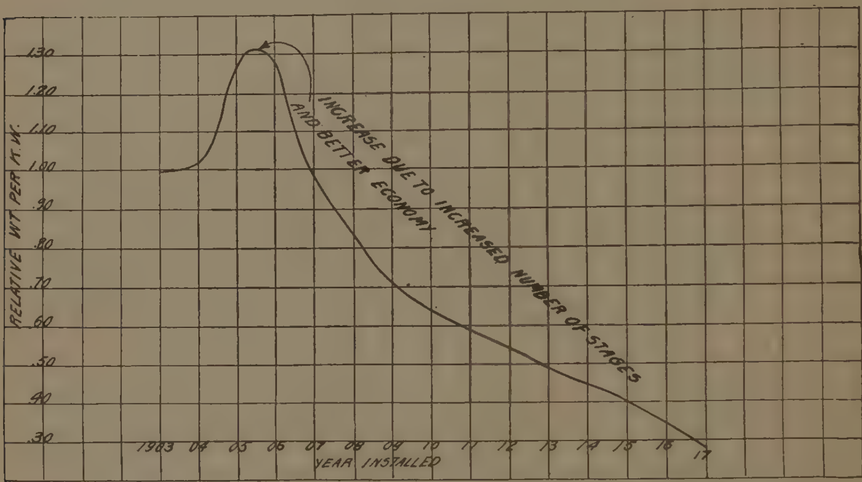


Fig. 3.—Weight per K.W. of Large Steam Turbines, for Successive Years, in Terms of Weight per K.W. of First 5,000 K.W. Unit.

Referring to the steam consumption curve, it will be seen that, regarding the steam consumption of the 5,000 K.W. Chicago machines as unity, the largest machine built in 1916 has a water rate which is exactly one-half of that of the Chicago machine. It is believed that this development in efficiency has not been paralleled by that of any other type of heat engine when it is considered that the original machines were competitive with existing apparatus. Coupled with the development above stated has been a very notable development in the capacity of single units (see Fig. 4), and this is not one of the least of the advantages of the steam turbine. The original machine, as stated above, was of 5,000 K.W. capacity, and this was very close to the maximum capacity of steam engine generating units available at that time. In 1906 the maximum capacity had

risen to 8,000 K.W., in 1908 to 14,000 K.W., in 1911 to 20,000 K.W., in 1915 to 35,000 K.W., and in 1917 there are two units under construction of 45,000 K.W. each. These figures refer to units in a single shell with a single generator. The largest engine-driven units ever constructed for central power station use were rated at 7,500 K.W.

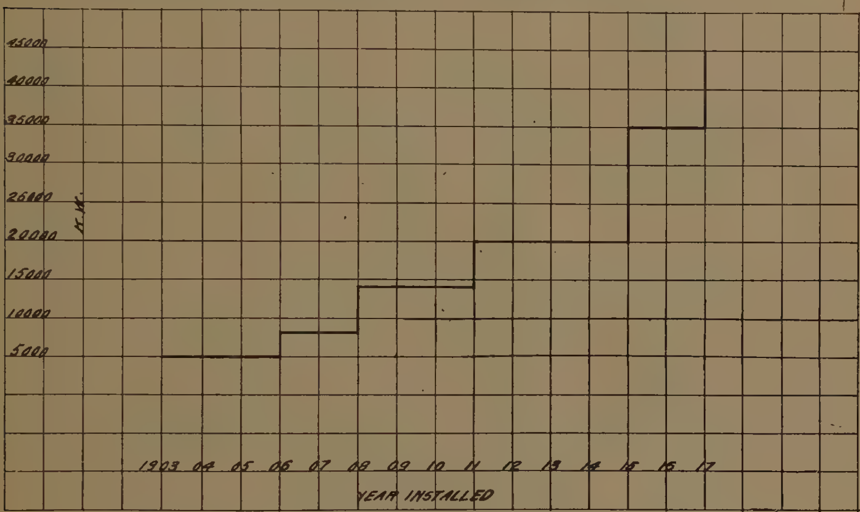


Fig. 4.—Capacity of Largest Steam Turbine Units Installed in Various Years.

It cannot be said with certainty that the ultimate capacity of single turbo-generator units is limited to the sizes now being built, although for the moment this is undoubtedly true. The limitation in the size of the unit is a limitation arising from the materials available for buckets and for bucket wheels, and from certain other constructional difficulties which may, or may not, be smoothed away by future improvements. Furthermore, an important limitation is the question of dimensions of pieces which can be transported by rail. Remembering, however, that in 1908 we could not foresee the possibility of making 20,000 K.W. units, and in 1911 we could not see the possibility of making 35,000 K.W. units, I have faith to believe that in a few years we will be building units of greater ratings.

The progress resulting from the production of better materials for use in buckets, bucket wheels and other parts

has been almost immediate, turbines of better efficiency being the consequence. This ought to interest steel manufacturers and induce them to lend an attentive ear to the requests made upon them from time to time by turbine builders, even although such inquiries at the instant involve a very small tonnage.

The development of steam turbines has proceeded along various lines. One of these is the determination of the best methods of using the energy in the steam with moderate ranges of steam pressure and steam temperature. This has led, as much as anything, to the use of a constantly increasing number of stages. Another line of progress has been in the direction of extending the pressure range at its lower end. It was found early in the progress of the development that the use of a very high vacuum was attended with improved results. At the time when the steam turbine began to be used, it was the accepted opinion, arising from limitation of steam engine design, that 27″ was as good a vacuum as it was desirable to obtain. The discovery that high vacuum was beneficial for steam turbines led to the early installation of condensing apparatus capable of giving 28″ vacuum, and progress in this direction led to 29″ as an ordinary, usual figure, and many stations in the country now operate throughout the colder months of the year with vacuum ranging between 29″ and 29.4″.

With the vertical turbine a very efficient development for securing the advantages of high vacuum was the use of the base condenser, which placed the condenser tubes very close to the buckets of the last wheel, and gave such enormous passages for the flow of the steam from the last buckets to the condenser tubes that the vacuum at the tubes was practically realized at the buckets without loss. With the adoption of the horizontal type some of this advantage of short passages, large areas, and close relationship between the last turbine wheel and the condenser tubes was lost temporarily, but recent constructions have practically eliminated this loss and it is now considered that further progress in the direction of bettering the vacuum is scarcely possible.

Still another line of progress is found at the upper end of the scale (see Figs. 5 and 6). The steam turbine lends itself well to the use of high initial pressures of steam and

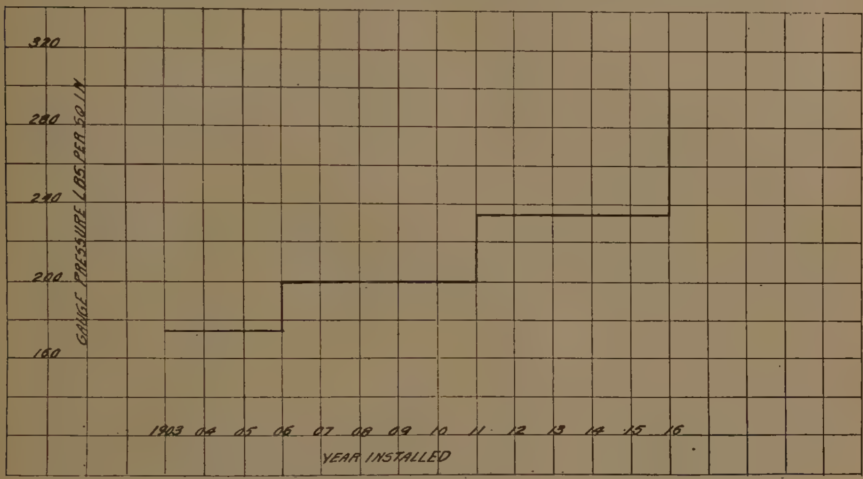


FIG. 5.—Highest Initial Steam Pressures Used in Large Steam Turbines.

also to the use of high temperatures (that is, high superheat). The original turbines were intended to operate with

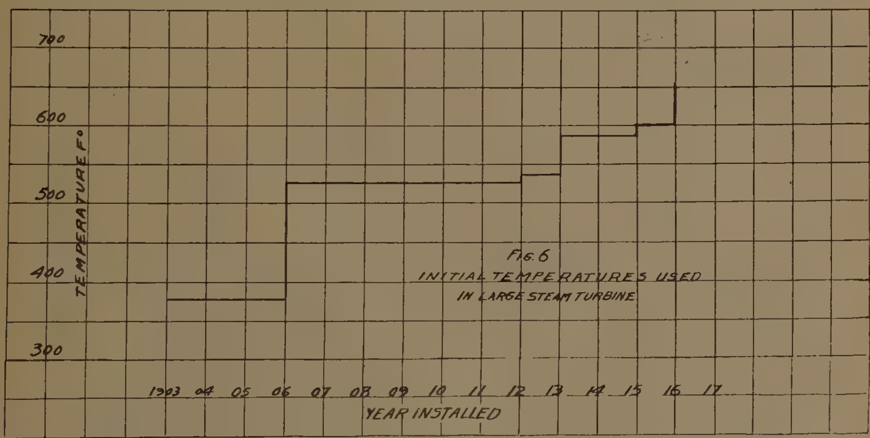


FIG. 6.—Initial Temperatures Used in Large Steam Turbines.

175 pounds steam pressure, without superheat, and owing to imperfect knowledge of the laws involved in the proper utilization of high superheat, it was for some time believed

that high superheat was not attended with a corresponding increase in efficiency. At this time, the laws involved in the proper utilization of high superheat are known, and its economy has been demonstrated. Increased boiler pressure is also known to give increased efficiency, and therefore turbines are now in use and under construction which will utilize the highest steam pressures and temperatures which the present state of boiler and steam pipe construction are capable of safely generating and handling. The situation may be summed up as follows: The highest steam pressure now in use is 300 lbs. per sq. in., while units are under construction intended for 350 lbs. pressure. The superheat is chosen so as to make the initial steam temperature fall between 600° and 700° F.

Further progress in this direction depends upon the practicability of building boilers and piping to continuously withstand greater pressures and upon the desirability of the investment from a commercial standpoint, considering the necessarily higher cost of such apparatus. It is safe to predict that higher temperature and higher pressure will be used following closely the development of better materials, of improved design, and increased experience on the part of the boiler builders.

The last great line of progress to be considered here has been the improvement in boiler-house efficiency. The average boiler efficiency in steel mill and blast furnace installations was, in 1903, and in many cases still is, about 60 per cent. In power stations at that time it ranged around 65 per cent. to 70 per cent. Recent boilers in central stations, including economizers, show efficiencies of 82 per cent. to 84.2 per cent. This increase in efficiency is chiefly due to improvements in stoking apparatus, to improvements in furnace construction, to the use of large boilers, and to the use of economizers. The economizer is a means of abstracting heat from the gases in their passage from boiler to chimney and imparting it to the feed-water. By abstracting this heat it lowers the temperature of the gases to a point just above the temperature at which moisture from the gases would be deposited on the economizer tubes, and it adds 4 per cent. to

6 per cent. to the thermal efficiency of the station. It is also possible, practical and commercially profitable to obtain a further addition to the thermal efficiency of about the same amount by inserting a feed-water heater in the flues after the economizer, of construction suitable to work with the deposition of moisture above referred to without excessive deterioration, and by such means to reduce the temperature of the outgoing gases to even as low as 125°.

With blast furnace gas, using the most modern equipment of superheaters, boilers, furnaces and premixing burners, and using gas which has passed through primary washers, and with the same attention to the operation which is met with in our best central stations, it is confidently believed that a boiler-house efficiency of 81 per cent. can be obtained in actual service.

Progress in increasing the energy output at the switchboard, per pound of coal fired into the boilers, has been dependent not only on improvements in the turbines, but also in condensing apparatus, and in the boiler house, and the combined result is, of course, what interests the user. Figure 7 has been drawn from the best data available, to show the progress that has been made. It will be seen that, starting in 1903, one pound of coal of 13,500 B.t.u. was capable of delivering .41 K.W. at the switchboard. Progress has been fairly uniform throughout the years to 1916, when we find that a pound of coal will deliver .82 K.W., or an increase in 13 years of 100 per cent.

One of the great difficulties met with in considering data concerning the operation of turbo-electric plants arises from the rapidity of turbine development. No sooner has a plant been installed and operated long enough to enable accurate tests to be made, than better apparatus has been designed and made available, so that the results of actual tests of power stations in operation never represent the state of the art. Machines which can be sold at time of test are always better than those which are being tested. No other prime mover has experienced such rapid development in efficiency, and no other prime mover is therefore subject to this difficulty. It

is, however, possible, given results from existing stations, to predict with certainty the results which will be obtained with turbines of the latest construction. The curve here

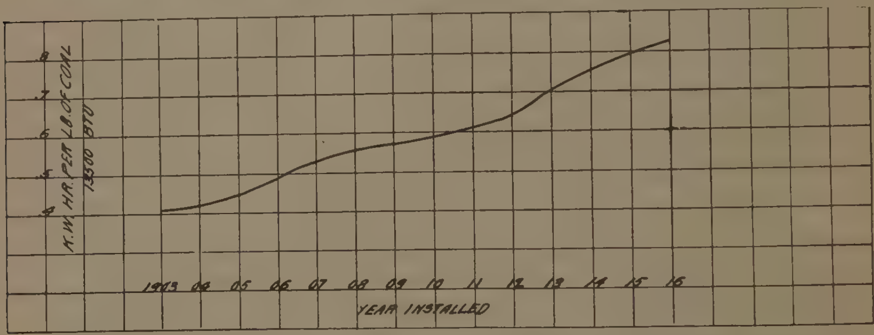


FIG. 7.—K.W.-Hours per Pound of 13,500 B.t.u. Coal, for Complete Electric Stations Using Largest Steam Turbines on Steady Load.

shown (Fig. 7) is based on actual station test results and therefore does not represent the possibilities at this time, but rather gives results substantially inferior to such possibilities.

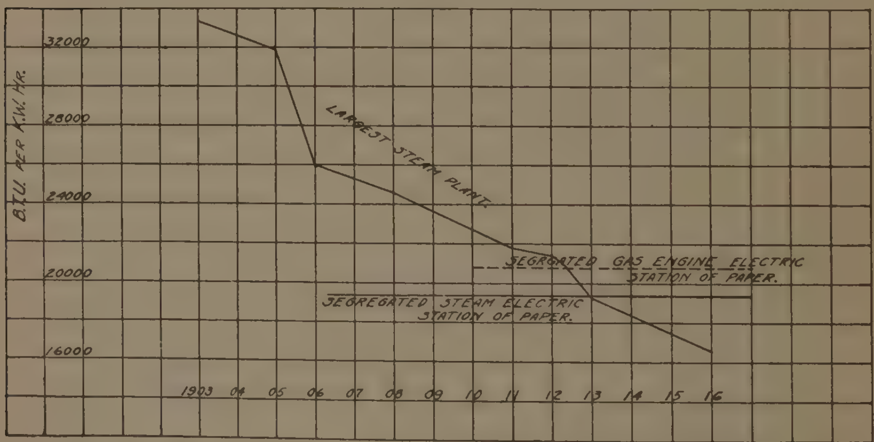


FIG. 8.—Heat Consumption, in B.t.u. per K.W.-Hour, for Complete Electric Stations on Steady Load. The figures in all cases include all power-plant apparatus, including auxiliaries and emergency reserves.

The extensive gas-engine installations which have been made in the steel mills of this country were decided upon at a period in the development of the steam turbine when, as

shown above, the showings which could be made were much inferior to the results of to-day. Therefore, the comparison between gas engine and steam turbine is on an entirely different basis at this time, and the problem ought to be now considered in the light of these latest results.

In order to exhibit the relative characteristics as regards first cost, operating cost and efficiency of plants containing gas engines as contrasted with plants containing steam turbines, layouts and data have been prepared covering a considerable number of plants, of which three plants have been selected as typical of the general situation. One of these plants is entirely driven by gas engines as prime movers. Another is entirely driven by steam turbines; while the third, hereafter referred to as "the combined plant" is a gas engine plant with such steam apparatus as is needed to give such a degree of operation-factor as to permit the operation of the plant with reasonable continuity, but nevertheless, not equally as able to operate under unfavorable conditions as the steam turbine plant.

As regards continuity of operation, these three plants would rank as follows:

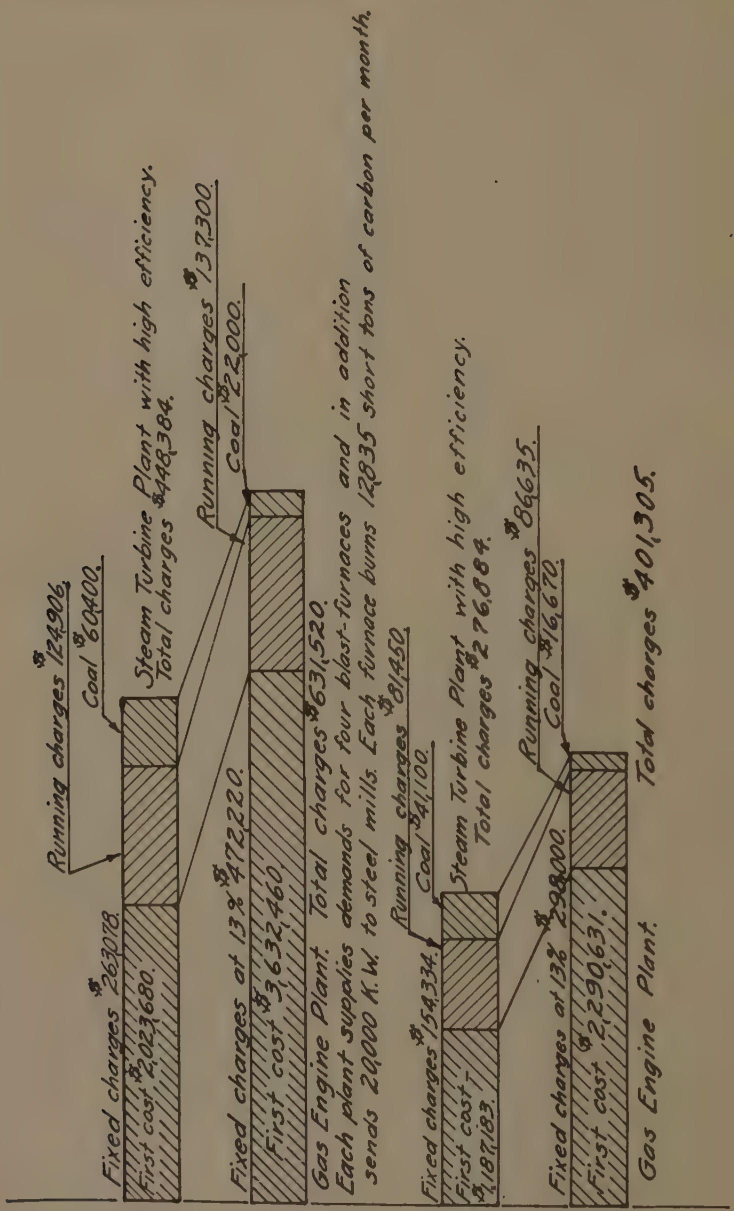
First, the steam turbine plant.

Second, the gas engine plant with steam reserve (combined plant).

Third, the all-gas-engine plant.

In preparing this information, a considerable choice presented itself as to the amount of emergency operating resources which would be provided to take care of the periods when gas supply is low in heat units and in quantity.

In a four furnace gas engine plant, supplied solely with blast furnace gas as a fuel, there would be considerable periods occurring frequently when steel mill apparatus would have to be shut down for lack of power. In the gas engine plant which has been chosen, gas producers are installed for the purpose of supplying fuel to the gas engines during these periods. These gas producers, of course, have no heat storage. They are not capable of giving out, during such periods, heat stored up during periods when the gas supply is abundant. Therefore, the reserve capacity



Complete Plant. *Segregated Electric Station.*

Fig. 9.—Chart of Comparative Charges for Four Furnace Plants. The total lengths for each case give total costs of every kind, including fixed charges, repairs, maintenance and operation, and make-up coal. All figures are dollars per year.

which can be provided in this way is not equal to plant No. 2, which contains steam turbines supplied by steam boilers which have heat storage capacity in the water thereof. The boiler capacity in this plant, in turn, is not nearly as great as in the steam turbine plant which, therefore, has considerably more reserve capacity due to the heat storage capacity of these additional boilers. Furthermore, in the case of the combined plant, and in the steam turbine plant to a greater degree, power can be produced for operation of steel mills when the gas supply is deficient, by the use of fuel, either oil, tar or coal, to supplement the gas supply. This is possible in the gas engine plant, but not to anything like as great a degree, as the gas producer capacity provided is not sufficient.

In making these comparisons, the size of plant which has been chosen is one which contains four blast furnaces, each capable of producing 550 tons of pig per 24 hours, with a coke consumption of 1800 pounds per ton of iron. The proper amount of electric generating apparatus for a steel mill has been provided of such capacity as to utilize the blast furnace gas of the full average quantity and quality; and all the other items necessary to constitute a complete, practical and modern blast furnace and steel mill plant of this capacity have been included.

The gas plant and the combined plant differ materially from the plant described in a paper on "Blast Furnace and Steel Mill Power Plants," * since they provide less capacity for operation during periods of lean gas and low gas volume, less capacity for heat storage, and since because of the elimination of electric storage batteries and direct current generating apparatus, and in other particulars, they go to the extreme in the utilization of the latest experience in gas engine manufacture and operation.

As the result of these differences, the first costs and operating costs of the gas and the combined plants are considerably lower than the figures above referred to.

In the paper referred to there was an allowance of an

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* "Blast Furnace and Steel Mill Power Plants," by R. H. Rice and S. A. Moss, Proc. Engr. Soc. of Western Pennsylvania, Vol. 33, No. 2, March, 1917.

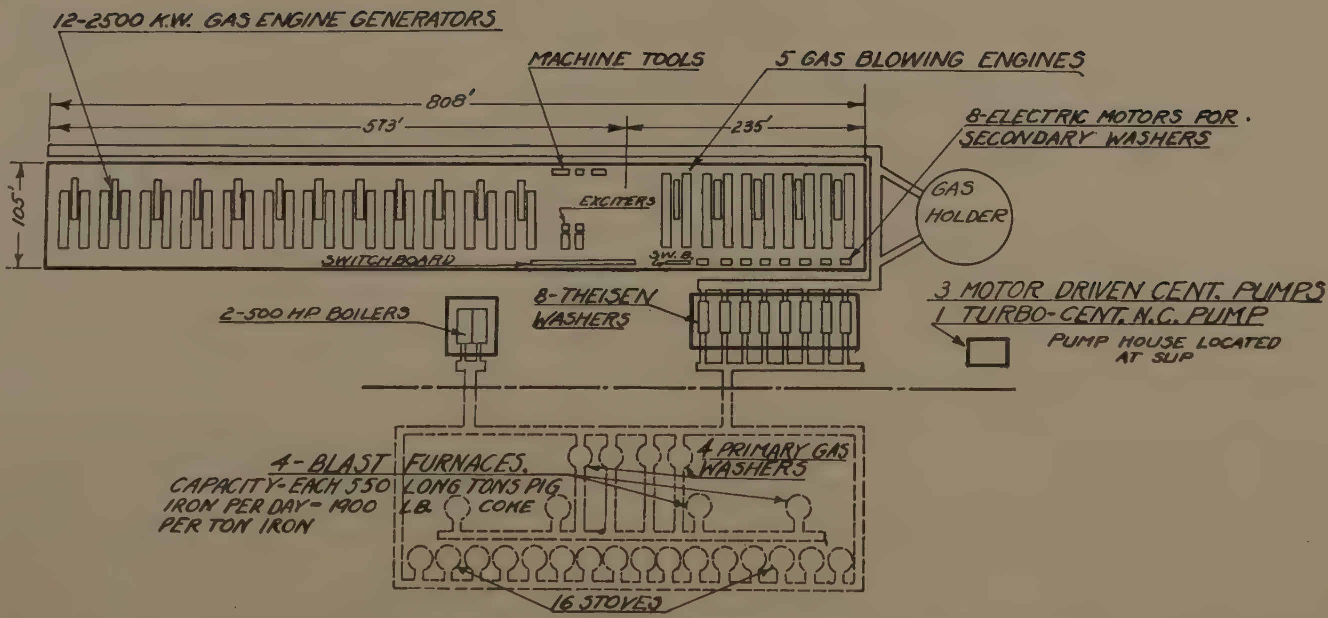


Fig. 10.—Layout of Four Furnace Gas-Engine Plant. The plant supplies all demands of four blast furnaces and in addition sends 20,000 K.W. of electricity to steel mills. In addition to Plant Apparatus shown, there are Reserve Gas Producers at the Open Hearth Plant.

additional 25% to normal costs to bring the cost up to those ruling at the time of the preparation of that paper. On account of the rapid change of cost of all sorts of apparatus, all costs have been restored to those ruling in the latter part of 1915 and the early part of 1916, which are considered as normal.

The steam turbine driven plant which has been used for these comparisons is supplied with apparatus, buildings,

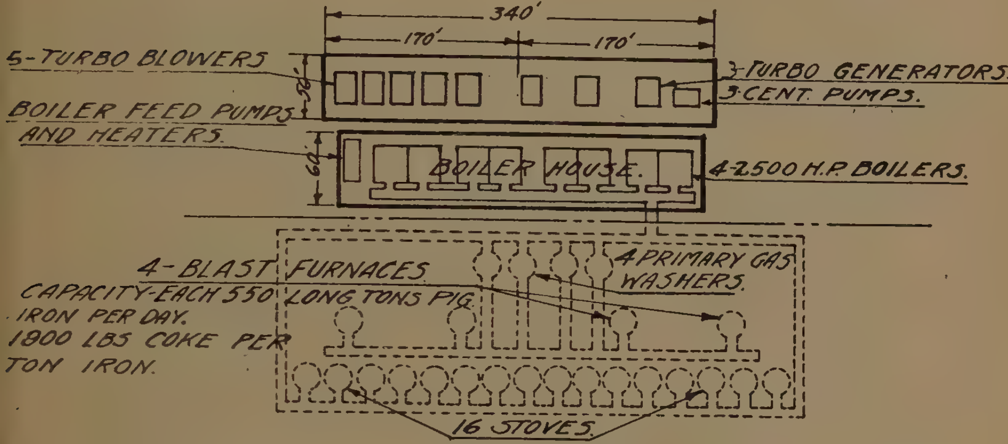


FIG. 11.—Layout of Four-Furnace Steam Turbine Plant.

etc., of suitable character for installation in a steel mill. While designed to be comparable in results obtained with the gas engine plant and the combined plant as regards continuity of service and protection by spares against shut down of the mills, it will, by its inherent characteristics, give greater continuity of service, and this fact must be taken into account in considering the merits of the various plants. This turbine plant utilizes the latest improvements in steam turbine manufacture now actually on the market. Comparing this plant with the plant of the Engineers' Society of Western Pennsylvania paper, some increases have been made in economizers and switchboards.

The specifications of these plants in detail will be found in appendices attached hereto, with the necessary information to enable a thorough understanding to be had of the

manner in which the figures have been put together. All the information obtained is based on the results of experience obtained with gas engine and turbine plants in actual operation over extended periods, and is believed to be thoroughly reliable.

In making up figures for the all-gas engine plant, an over-all efficiency of the main units has been taken of 20%. This figure has been taken in order to conform to the views of engineers who have been consulted and who are familiar with the practical operation of gas engine stations, but it is, in the judgment of the writer, too high a figure to use for gas engines operating under variable load in steel mill service. The curve of efficiency of a gas engine is a steep one, and efficiency rapidly falls off with reduction of load, due first, to the fixed mechanical losses, and second, to the variations in the gas which unfavorably affect the efficiency of operation much more seriously at light loads. If this figure is taken at 17%, which, in the opinion of the writer is as high a value as should be used for variable load, the efficiency of the all-gas engine plant would be reduced to 15.9%. This matter is one which will, no doubt, receive the careful attention and analysis of engineers who are seriously discussing the installation of a large plant of this character.

The units have been chosen with due reference to economy, flexibility and reliability, and in the gas engine installations include the largest units known to be available, with spares. In the turbo-blower house one unit per furnace, as contemplated, has become standard practice, with one spare. In the turbo-generator station, the three 12,000 K.W. units chosen provide one spare and follow central station practice and experience in the use of the largest units which will give the flexibility desired.

Table No. 1

COMPARATIVE COSTS OF FOUR-FURNACE PLANTS

First Costs	All Gas	Gas Engines with Steam Reserve	Steam Turbine
Secondary Washers and Pipes	$120,660	$120,660	......
Electric Station	2,094,450	2,164,450	$709,640
Blowing Station	1,001,350	1,085,350	536,304
Pumping Plant	246,000	246,000	121,496
Boiler Plant	30,000	104,500	656,240
Gas Producers	100,000	......	......
Gas Producer Auxiliaries	40,000	......	......
Total First Cost	$3,632,460	$3,720,960	$2,023,680
Running Charges $ per year			
Secondary Washers	$11,300	$11,300	......
Electric Station	72,000	72,000	46,396
Blowing Station	34,000	34,000	21,920
Pumping Plant	5,000	5,000	2,400
Boiler Plant	5,000	6,000	54,190
Gas Producers	10,000	......	......
Running Charges Total	137,300	128,300	124,906
Coal at $2.00 ton, 50c firing	22,000	48,600	60,400
Fixed Charges at 13%	472,220	483,725	263,078
Total Charges, $ per year	$631,520	$660,625	$448,384

In considering the effect of first costs on charges, I have included fixed charges, which consist of taxes, interest and obsolescence or amortization. (Depreciation is included under running charges as repairs and maintenance, and under fixed charges as obsolescence.) Fixed charges are taken for both gas and steam plants as 13 per cent. This is a customary figure for gas-engine plants, while steam turbo-electric stations often use a lower figure in the neighborhood of 11 per cent. Therefore, the use of 13 per cent.

for both is relatively favorable to the gas engine. Fixed charges may be itemized as follows:

Interest (on bonds or capital invested)	5%
Taxes	1%
Insurance	1%
Obsolescence (amount laid by as a sinking fund to replace or amortize the plant)	6%
Total	13%

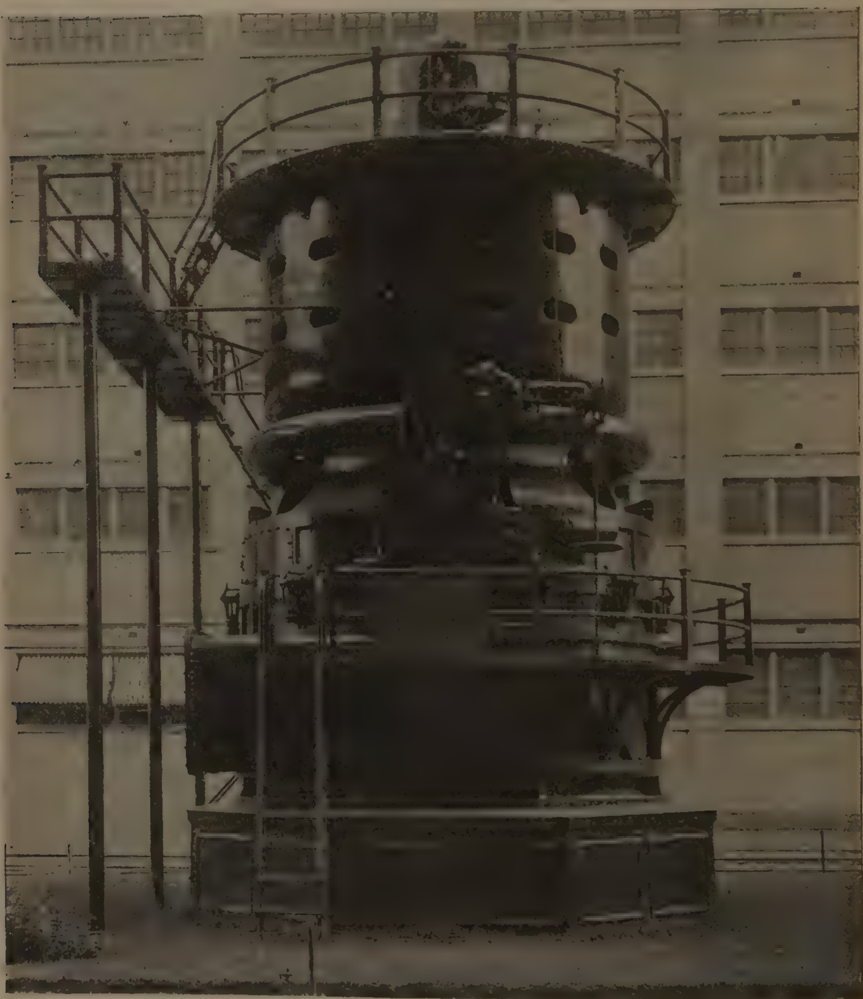


Fig. 12.—First Large Steam Turbine, 5,000 K.W., Commonwealth Edison Co., Chicago, Ill

Running charges include actual cost of operating the plant, and also maintenance and repairs, sufficient to keep the plant in first-class condition up to the time it is fully amortized. The only charges are therefore the fixed charges, the running charges and the cost of coal, for emergencies.

In order that it may be seen that all the saving in total charges is not realized in the electric station, Table 2 is given to show the first cost and charges of the electric station by itself.

TABLE No. 2

SEGREGATED ELECTRIC STATION

Fraction of Plant, Supplying 20,000 K.W. to Steel Mills.

First Costs	All Gas	Gas Engines with Steam Reserve	Steam Turbine
Secondary Washers and Pipes	$91,400	$89,300	......
Electric Station............	1,979,000	2,014,000	$681,254
Pumping Plant............	113,100	91,000	59,689
Boiler Plant...............	1,131	62,700	446,240
Gas Producers.............	75,700	......	......
Gas Producers Auxiliaries...	30,300	......	......
Total First Cost.........	$2,290,631	$2,257,000	$1,187,183
Running Charges $ per year			
Secondary Washers........	$8,570	$8,370	......
Electric Station............	68,000	67,000	$44,500
Pumping Plant............	2,300	1,850	150
Boiler Plant...............	195	3,600	36,800
Gas Producers.............	7,570	......	......
Running Charges, total...	$86,635	$80,820	$81,450
Coal at $2.00 per ton, 50c Firing.................	16,670	29,200	41,100
Fixed Charges at 13%......	298,000	293,300	154,334
Total Charges, $ per year .	$401,305	$403,320	$276,884

From a comparison of Tables 1 and 2 it will be seen:

Table 1

Saving in first cost by use of steam turbines in complete plant, about $1,600,000.

Saving in total charges by use of turbines in complete plant, about $190,000.

Table 2

Saving in first cost by use of turbines in electric station, about $1,000,000.

Saving in total charges by use of turbines in electric stations, about $120,000.

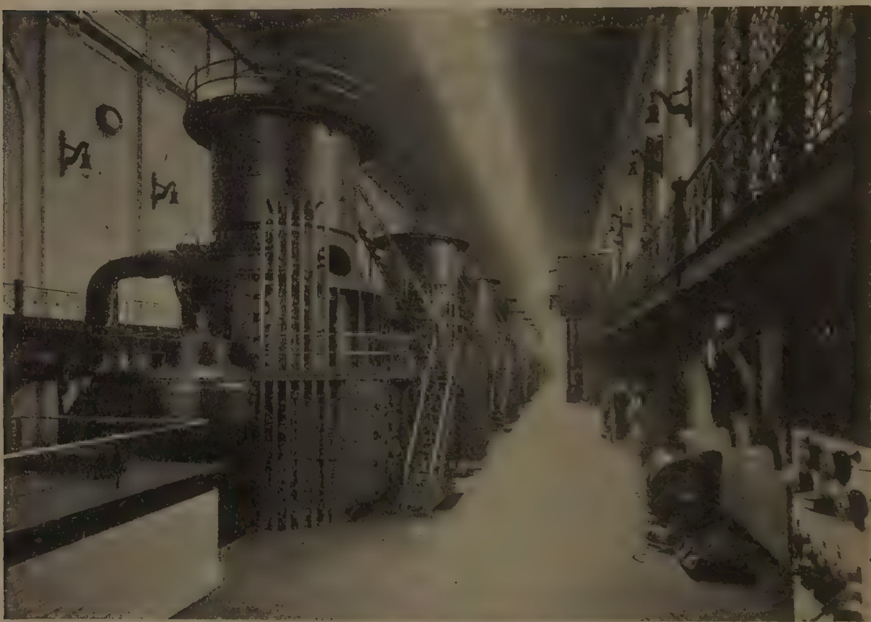


FIG. 13.—12,000 K.W. Steam Turbines, Commonwealth Edison Co., Chicago.

Attention should be called to the fact that the apparatus which has the lowest first cost has also the lowest total charges. In other words, by refraining from spending $1,600,000, a saving in total charges of over a quarter of a million dollars will be realized. It is usually the case that the apparatus of higher first cost has lower running charges which provide income necessary to take care of the fixed charges. In this case, the lower operating costs are partly produced by the lower fixed charges from the smaller in-

vestment and partly by the fact that the running charges of the lower cost apparatus are themselves lower.

Figure 8 shows the heat consumption of steam turbines of the largest sizes built from 1903 to 1916. There are also given lines showing the steam and gas electric stations above mentioned. The turbine curve and the gas-engine line represent over-all performances on the same basis.

The thermal efficiencies of the segregated electric station comparing the two types of prime mover, including auxiliaries and emergency spares, are as follows on the basis of steady load condition:

THERMAL EFFICIENCIES OF A COMPLETE STATION

All Gas Engine Plant of paper............	18.5 %
Gas Engine Plant with Steam Reserve........	16.5 %
Turbo-generator Plant of paper............	17.60%
Largest Turbo-generator Plant (Fig. 8).......	20.80%

With variable loads the thermal efficiency of the turbine plant will hold up closely to these figures, while the gas engine plant is known to fall off considerably under such operating conditions.

The City of Chicago is served exclusively by turbo-electric generating stations which, including apparatus in operation or under construction, have an aggregate capacity of 460,000 K.W. It is roughly estimated that a gas engine plant of this capacity would require about 180 units and cost complete about $33,000,000, while if the most modern turbines of maximum size were installed, ten units would be sufficient and the cost complete would be less than $15,000,000. The saving in first cost would therefore be over $18,000,000 in favor of the turbine plant. If land values were to be included, this figure would, of course, be largely increased.

The extent to which the turbine has displaced all other types of power apparatus in central stations is well shown by a study of the history of such stations in our large cities. At the introduction of the turbine in 1903, Chicago was entirely served by steam engines. To-day turbines are used exclusively. In New York the engine stations are either shut

down completely or are in process of complete replacement by turbine units and the process is already perhaps 90 per cent. completed. In Boston, after trials of all types of generating units, including gas engines, turbo-generators have replaced the others almost exclusively, and no one seriously considers to-day the use of any other means of generating power in our central stations.

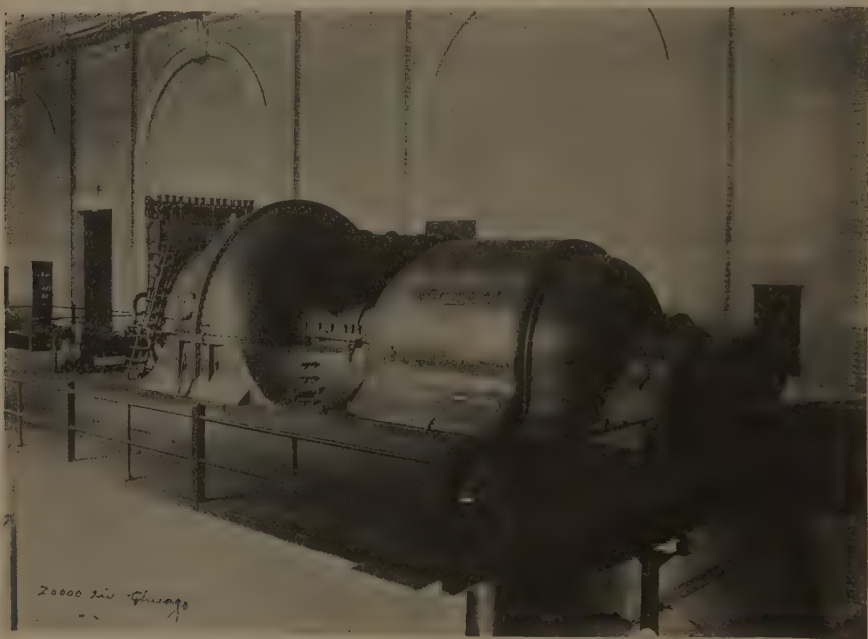


FIG. 14.—Modern 20,000 K.W. Steam Turbine, Commonwealth Edison Co., Chicago.

No attention will be paid in this paper to the relative merits as a piece of blowing apparatus of the turbo-blower and the gas engine. These points have been fully discussed in previous papers.

It is, however, proper to point out that not the least of the advantages gained by steam turbine operation is the greater reliability that results therefrom. This, in the case of the turbo-blower, was realized even in the first blast furnace apparatus installed which operated continuously

for a period of three years and eight months with a total time out of service of six hours. In the operation of blast furnaces in steel mills, continuity of service is of the utmost importance, not only in the mill where numbers of men have to be laid off in case of a failure of the power supply, but to an added degree in a blast furnace where failure of the blowing apparatus gives rise to tremendous expenses if this failure results in taking the furnace out of blast.

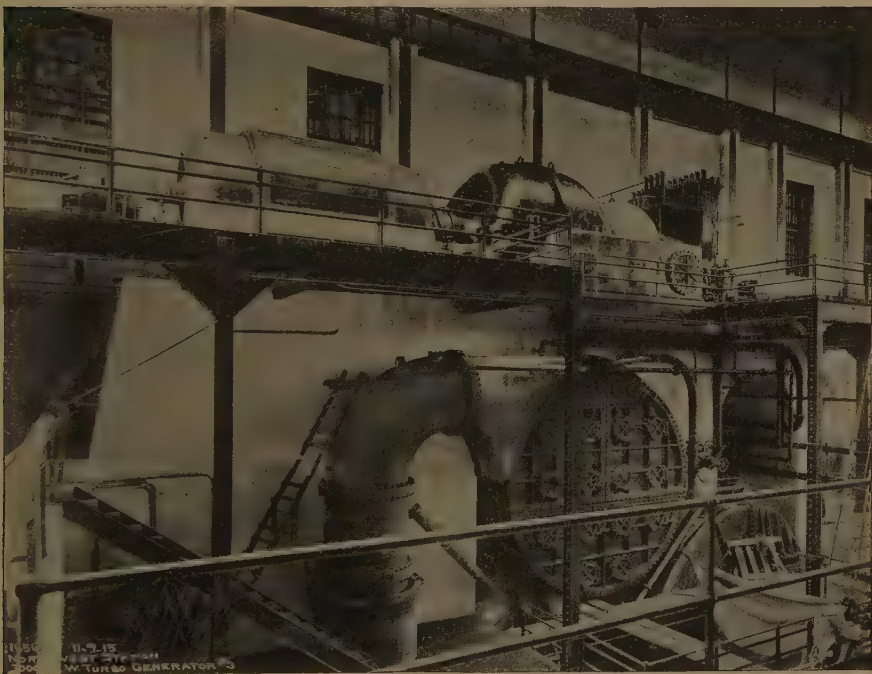


Fig. 15.—Modern 30,000 K.W. Steam Turbine, Commonwealth Edison Co., Chicago.

In fact, in all the turbine development which has taken place, an equally continuous development has taken place in its practicability; which includes continuity of service, freedom from disabling accidents, range of economical load capacity, ability to carry momentary overloads, low cost of attendance, repairs, and other operating expenses.

The actual complete disabling of the turbine unit to-day

is extremely rare and when accidents do occur, they usually involve only a temporary increase in the steam consumption of the unit without interfering with the possiblity of operating it. One, or several stages, of a turbine of modern type may be disabled without putting the unit out of business. In this respect, there is no doubt that the turbine is greatly superior to the steam engine which it replaced. Bucket constructions have been worked out of great strength, and the causes for bucket failures have been definitely located and substantially removed; and turbines are so constructed nowadays as to

FIG. 16.—Chicago Territory.

reduce the consequences of bucket failure to a minimum by largely confining the damage to the stage in which it originates. Water in the steam supplied to a turbine affects it by undue wear of buckets if of considerable quantity and long continuance of the condition, if in large quantities, by momentary reduction of speed and by roughness of operation. Accidental damage to the turbine due to this cause is so rare as to be almost entirely absent. The use of modern steam conditions, as is here proposed, eliminates this question

entirely. The multiplicity of moving joints and connections necessarily used in any form of reciprocating engine, by their rapid wear and the necessity of constant attention, constitute a menace to the reliability of such power units. Another advantage of the turbine which has been fully maintained is the automatic character of its lubrication.

The conclusions set forth are based entirely upon accomplished facts without any reliance upon prophecy as to future developments or even upon utilization of developments already in hand. There is no reason to believe that turbine development has ceased. The trend of the curves of Figures 7 and 8 is definitely against this hypothesis. We know for instance that higher steam pressures and steam temperatures will result in increased thermal efficiencies. Calculations easily made from known data show that, by the use of an initial steam pressure of only 500 lbs. per sq. in. with steam temperatures now in use, with units of maximum size and with the apparatus necessary to reduce the flue gas temperature to 125°, a thermal efficiency for the station, at steady load, of about 28 per cent. is attainable. Improvements in turbine construction are also possible and no ground exists for the belief that turbine development is at an end.

Various combinations of gas engines with other prime movers have from time to time been proposed and at least one of them has been tried out on a considerable scale with results not encouraging to the future of such combinations. One of the most talked of combinations consists of a gas engine, the hot jacket water of which is utilized to furnish steam for a low pressure turbine. Such a combination would add three or four units to the thermal efficiency of a wholly gas engine station but this saving would not warrant the adoption of the system with its increased complication, with its undesirable interdependence of gas and steam units and the resulting jeopardizing of continuity of service.

The increased investment required for such a plant would result in increased fixed charges; while the increased complication would increase the running charges; and these increases would more than neutralize the effect of the increase

in efficiency. For the above reasons this combination is not a factor in modern power generating systems.

It should be pointed out that one of the difficulties connected with maximum utilization of the heat units available in the gas from blast furnaces, arises from the fact that utilization of these heat units is only one of the incidents

FIG. 17.—20,000 K.W. Steam Turbine, Cleveland Electric Illuminating Co.

necessarily attendant upon the operation of blast furnaces and the operation of steel mills. The attention of the management is largely fixed upon the question of production of pig iron and steel. The question of production of electricity and of blast are secondary. However, the savings which can be made over existing practice are so large, that they warrant giving this question the utmost attention. I, therefore, suggest the creation of a separate department of the works to handle this question of power generation, at the head of which should be an engineer of the necessary attainments and experience, whose sole duty should be to see that this power plant operates with the utmost economy and

continuity. In this way, I believe that results equal to those obtained every day by our central power stations can be realized with equal facility in blast furnace and steel mill installations.

The utilization of waste heat from open-hearth and heating furnaces (and perhaps even from Bessemer convertors),

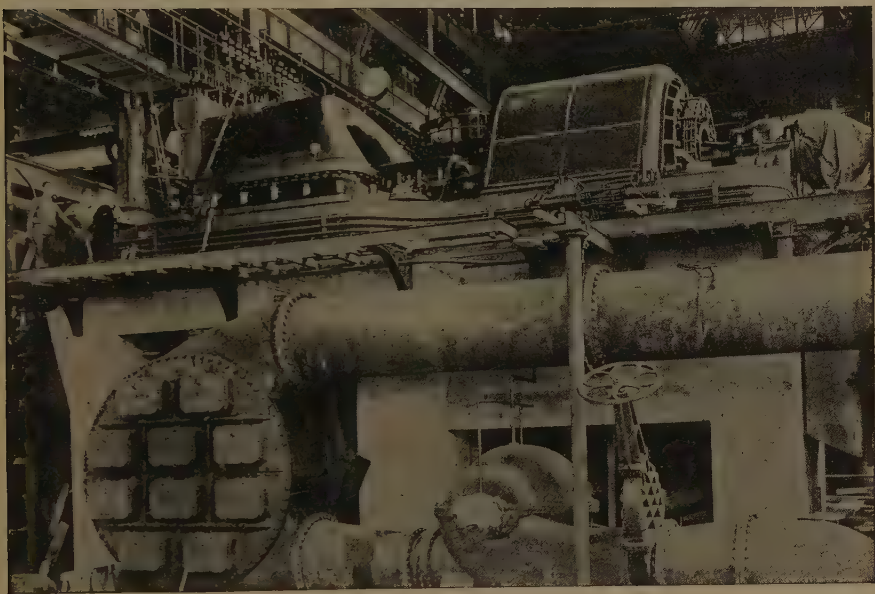


FIG. 18.—15,000 K.W. Steam Turbine, New Orleans Railway and Light Co.

to the limit, and of by-product gas resulting from the manufacture of coke, the installation of modern steam turbine plants at all furnaces, capable of utilizing blast furnace gas to the maximum extent possible, and the tying together of all plants in a closely developed section like Pittsburgh by a suitable network of electric cables, will probably render it unnecessary to develop any power in such a district by the use of raw fuel. In fact, it is confidently believed that such complete utilization of the heat available in any of our large steel producting centers will render it possible to supply considerable electric energy for external purposes at a very attractive rate. (Applause.)

APPENDIX A

Specifications for Blast Furnace Plants

Figures in the paper apply to an installation of blast furnaces in a steel mill of which the principal constituent elements are given below. The data upon which all the values herein given depend were set forth in a paper before the Engineers' Society of Western Pennsylvania, as referred to on page 11 in the paper; except that economizers have been added and details of feed-water heating system re-arranged for the steam plant to bring the efficiency of the plant up to the latest practice.

Blast Furnaces.

Four blast furnaces have been included in which it is expected that carbon will be consumed with a total amount of 12,835 short tons per furnace, per average month of 730 hours. This figure corresponds to an output of 550 long tons of pig per day with a coke rate of 1,800 pounds per long ton and considering 85.2 per cent. of the weight of coke as net carbon passing into the gas.

By means of the following formula quantity of air and quantity of gas produced for each pound of carbon leaving the furnace in the gas is given below. These computations are derived from a gas analysis and the values obtained are in cubic feet at 14.7 lbs. per sq. in. and a temperature of 60° F. and this quantity is substantially equal to cubic feet at 30″ mercury and 62° F. temperature.

N_2 = percentage of N in the gas.

C = the sum of the percentages of gases containing carbon.

Then, $39.6\ N_2/C$ = cubic feet of air per lb. of carbon.

$3140/C$ = cubic feet of gas per lb. of carbon.

The air above computed is actual air after allowances have been made for slip, etc., and is the figure indicated on the

governing beam of a turbo-blower with a properly calibrated air governing apparatus.

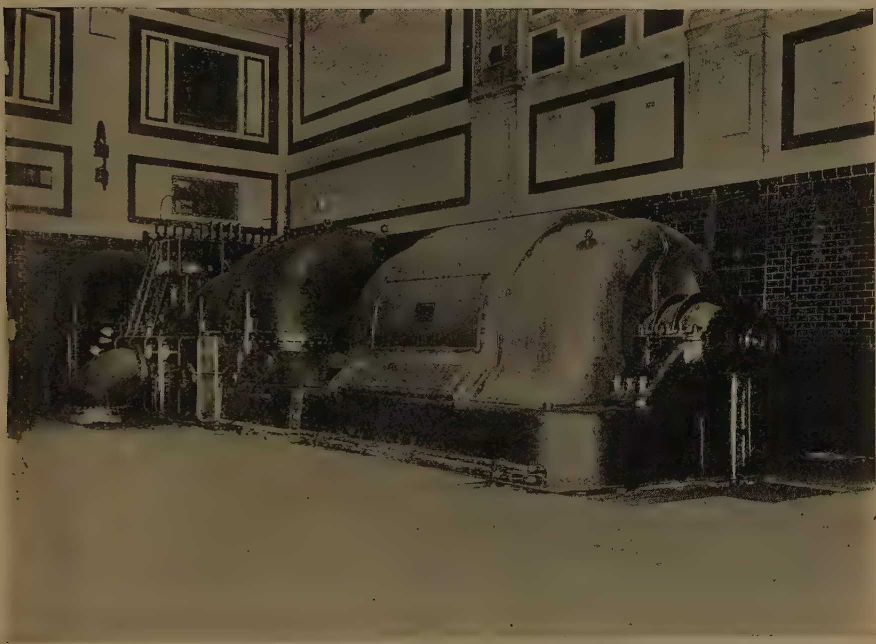


FIG. 19.—30,000 K.W. Steam Turbine, Waterside Station, New York Edison Co.

The carbon above referred to is the carbon in the gas and consists of the net carbon in the coke and in the limestone, etc., less the carbon in the pig, flue dust, etc.

The gas analysis used for this case is as follows:

		Per cent.
CO		26.2
CO_2		12.9
CH_4		0.1
C	= Sum of gases containing carbon	39.2
H_2	=	3.5
N_2	= Nitrogen by difference	57.3
		100.0

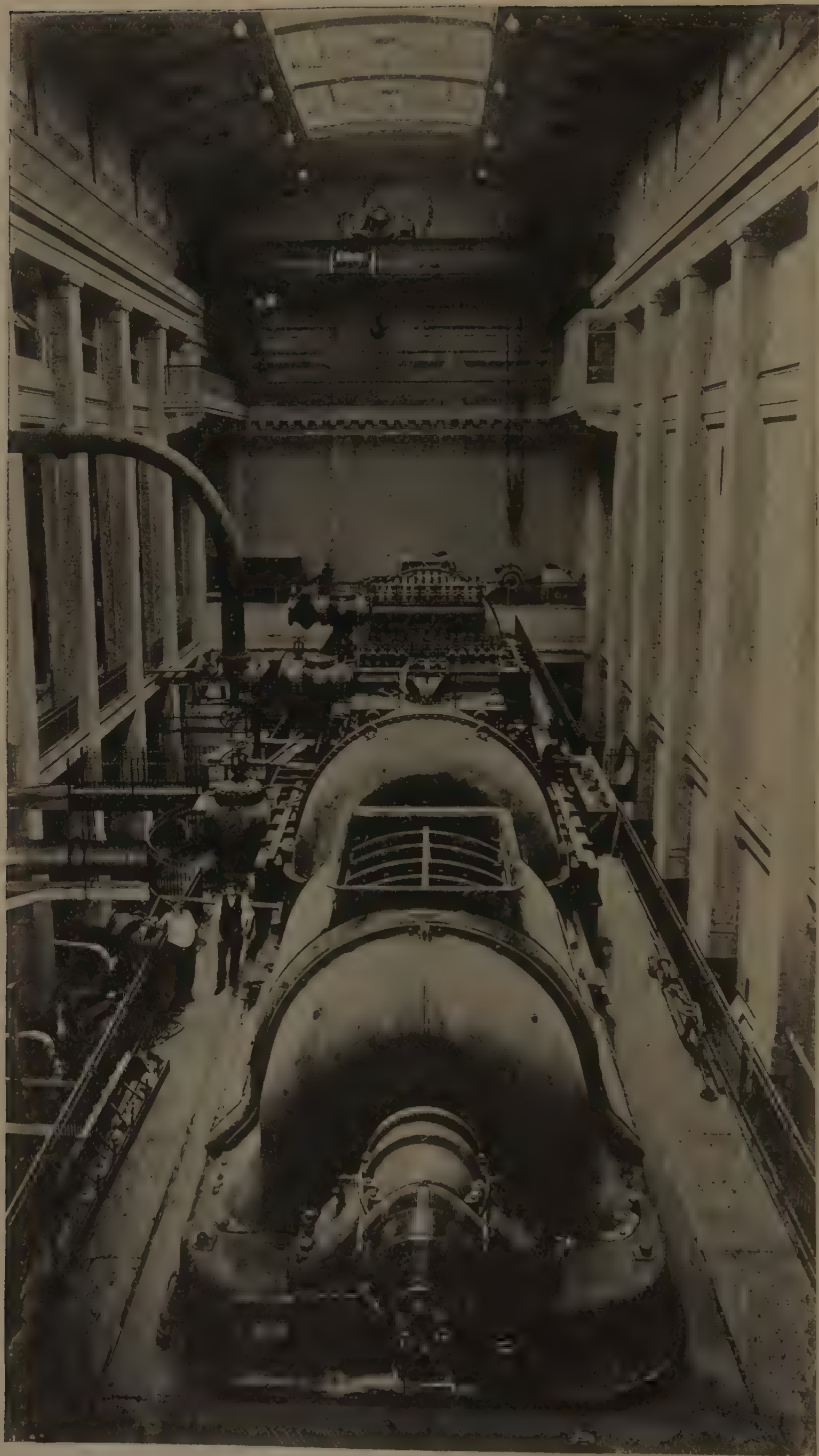


Fig. 20.—30,000 and 35,000 K. W. Steam Turbines, Philadelphia Electric Co.

The lower or net heating value of this gas is computed to be 95.5 B.t.u. per cu. ft.

Substituting in the above formulae the value of N_2 and C for the above gas analysis, we have for these furnaces:

Cu. ft. of air per lb. of carbon = 57.9
Cu. ft. of gas per lb. of carbon = 80.1

The total heat in the gas will then be:

$12{,}835 \times 2{,}000 \times 80.1 \times 95.5 \times 4/730 = 1{,}076$ million B. T. U. per hour.

All the gas produced passes through primary washers, and 30 per cent. of the gas is assumed to be used in the stoves.

General Characteristics of the Plant

The plant is laid out to be capable of supplying all blast furnace demands for air, water, steam and electricity, and also during week-day hours to supply to steel mills, per furnace, 5,000 K.W. of electricity, or a total for the plant of 20,000 K.W. of electricity. If, and when, the gas is insufficient to generate sufficient power for the full output of the steel mills, coal must be used to make up the deficiency. The cost of this coal is included in the figures of Table 1, last item under charges, at $2 per long ton delivered at fire-room door, and containing 13,500 B.t.u. per pound, plus 50 cents per ton for firing and ash-handling.

The gas-engine plant has apparatus provided for burning this coal in such emergencies.

The entire plant in either case is assumed to be located on a river or a great lake, and it includes apparatus for unloading ore, storing it and delivering it to the furnaces; and water is supposed to be of such quality that it is proper for use without purification. There is also included in the figures a water intake system with conduits and standpipes.

APPENDIX B

Four-Furnace Combined Gas-Engine Plant With Steam Reserve.

This plant includes a gas electric and a gas blowing station; also an electric pumping station. There are steam spares provided in all cases for emergency use. This includes a boiler house supplying regularly a small amount of steam for various purposes connected with the plant, but with sufficient reserve capacity so that by coal firing, steam for the emergency spares may be supplied when necessary. Gas holders are provided to store a comparatively small amount of gas, and furnace gas can be turned on or off and used under steam boilers as occasion demands, coal being used to make up any deficiency. The average amount of coal used for make-up is small.

The system includes a reserve of boilers and steam spares which have been found necessary in practice, so that the blast furnace, steel mills and pumps will seldom have to be shut down.

Boiler Plant for Gas Engine Station

The following table shows the steam used in million pounds per month in this boiler plant:

Operation of electric station steam turbines......	23.57
Power Station, miscellaneous..................	2.13
Gas Washer Station, miscellaneous.............	0.47
Blast Furnace, miscellaneous..................	9.47
Total Steam.........................	35.64

The following quantities are used:

Heat added in boilers—1,135 B.t.u. per pound of steam.

Heat consumption of boilers at 65 per cent. efficiency—
$1,135 \times 35,640,000/730 \times 0.65 = 85$ millions B.t.u. per hour.

Coal used in addition to gas—8,800 long tons per year at \$2.50 = \$22,000, same as in Plant C.

Normal coal to make margin same as in Plant C as found later, 43 million B.t.u. per hour. Normal coal cost $\frac{43,000,000 \times 24 \times 6 \times 52 \times 2.50}{13500 \times 2240} = \$26,600$ per year.

Total coal cost \$48,600.

Gas Electric Station

Alternating current circuits are provided which are supplied by gas-driven electric generators; one of these circuits has steam turbines floating on the line at light load which are capable of taking greater load in emergencies. Gas engines are installed with a maximum capacity of 30,000 K.W. and a steam turbine with a capacity of 2,000 K.W.

POWER DISTRIBUTION IN K.W.

	K.W.
Blast Furnace, miscellaneous	850
Pumping Station	720
Secondary Gas Washers	642
Blowing Station	58
Electric Station, miscellaneous	650
Steel Mills	20,000
Total Power	22,920
Steam-Turbine Power	725
Gas-Engine Power	22,195
Total Power	22,920

As already explained, 20 per cent. efficiency is used, giving a gas engine consumption of $22,195 \times 3410/.20 = 378,000,000$ B.t.u. per hour.

The maximum amount of electric power which is needed

for week-day working hours in the steel mill is 20,000 K.W., that is, 5,000 K.W. per furnace. The gas from the furnaces is, on the average, more than sufficient to furnish this amount of power, but on account of fluctuations of both load and gas, a greater load than that above specified would

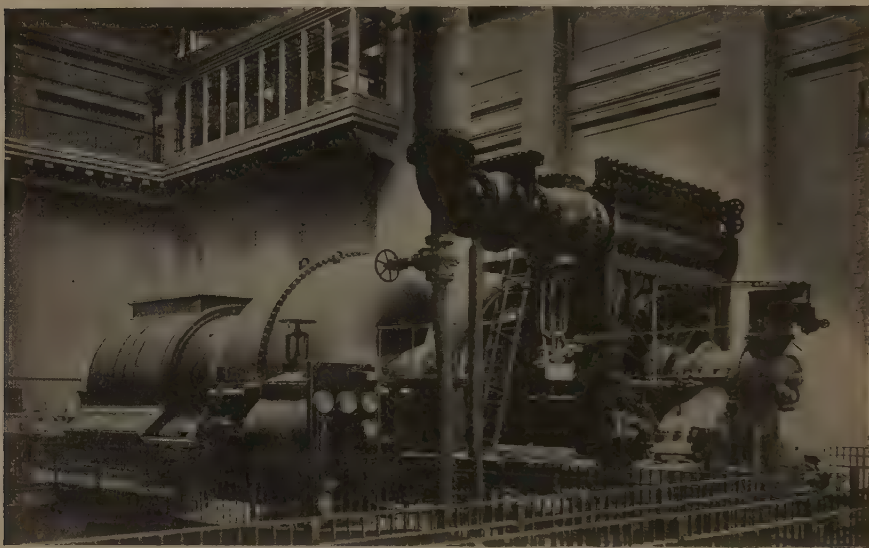


Fig. 21.—35,000 K.W. Steam Turbine, Philadelphia Electric Co.

involve shut-downs of the mill for unduly protracted periods when the gas is bad, or else it would involve undue expenditure for make-up coal.

Gas Blowing Station

Seventy-four cu. ft. of blower displacement have been provided per pound of carbon. The blowing engine gas consumption is taken at 8,534 B.t.u. per gas I.H.P. hour. This is a test figure for the best plant investigated with an engine having limited overload capacity. Another plant gave 15,000 B.t.u. per gas I.H.P. hour. The average ratio of theoretical adiabatic air card to gas indicator card is 0.844. The air-tub displacement per furnace is 12,835 ×

$2{,}000 \times 74/730 \times 60 = 43{,}400$ cu. ft. per min. The average theoretical power for adiabatic compression (at 15 lbs. per sq. in. air pressure) is 5 HP. per 100 cu. ft. of air per min. Gas blowing engine I.H.P. per furnace is $434 \times 5/0.844 = 2{,}571$. Gas blowing engine heat consumption is $8{,}534 \times 2{,}571 \times 4 = 88$ million B.t.u. per hour.

Pumping Station

WATER DISTRIBUTION IN GALLONS PER MINUTE

Secondary Washers	920
Electric Station	5,310
Blowing Station	2,080
Blast Furnaces	6,667
Make-up and Miscellaneous	1,000
Total Plant Water	15,977

Heat balance for complete gas-engine plant with steam reserves:

	Million B.t.u. per hour
Boilers	85
Electric Station	378
Blowing Station	88
Stoves at 30% of Total Gas	323
Margin	245
Total	1,119
Heat from Normal Coal	43
Heat from Gas	1,076

The cost of the complete plant, including reserve boilers and steam spares in electric blowing and pumping station, are given in the first column in Table 1 in the main body of the paper, and need not be here repeated.

APPENDIX C

Four Furnace All Gas Engine Plant

This plant has no steam blowing or electric units, with one steam pump used only for emergencies. Reserve gas producers are provided, which normally relieve the Open Hearth Producers, so that both sets are running light. For emergencies, the regular producers are run on their furnaces at full load, and the reserve producers are diverted to the gas engines. There is thus no heat used during normal operation by the engine producers. Emergency coal, $22,000 per year.

A boiler plant supplies steam as in B, except for steam turbines, giving 12,070,000 pounds per month and requiring $1{,}135 \times 12{,}070{,}000/730 \times 0.65 = 29{,}000{,}000$ B.t.u. per hour. The electric station will have gas engines exclusively, supplying the entire power of B and requiring $22{,}920 \times 3{,}410/.20 = 391{,}000{,}000$ B.t.u. per hour.

HEAT BALANCE FOR ALL GAS PLANT, IN MILLION B.T.U. PER HOUR

Boilers	29
Electric Station	391
Blowing Station	88
Stoves	323
Margin	245
Total	1,076

APPENDIX D

Four-Furnace Steam Turbine Plant

This plant is equipped with large, modern boilers, with all improvements and with economizers. The boilers can burn coal as well as gas. The steam conditions are such as would be used in modern stations, 235 lbs. per sq. in. gauge,

200° superheat, 28.5″ vacuum. There are motor-driven, circulating pumps directly attached to the generator steam turbines and not included in the general pump station. Throughout the plant motor-driven auxiliaries are also used

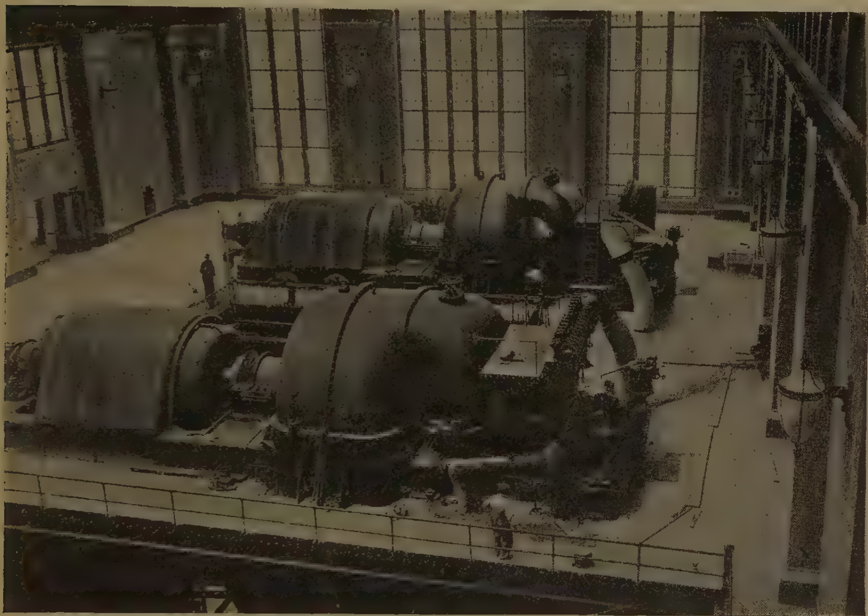


Fig. 22.—Two 25,000 K.W. Steam Turbines, Essex Station, Public Service Electric Co. of New Jersey.

with enough steam-driven auxiliaries for emergencies and to heat the feed water to an amount consistent with the best efficiency of the boiler economizers. Plant service and Blower Circulating Pumps are condensing steam driven.

Turbo-Electric Station

There are three turbo-generators rated at 12,000 K.W. continuous load; two of these to be operating continuously and one to be a spare, for regular week-day load. There are small motor-generator and turbo-generator sets for excitation, feed-water heating, etc.

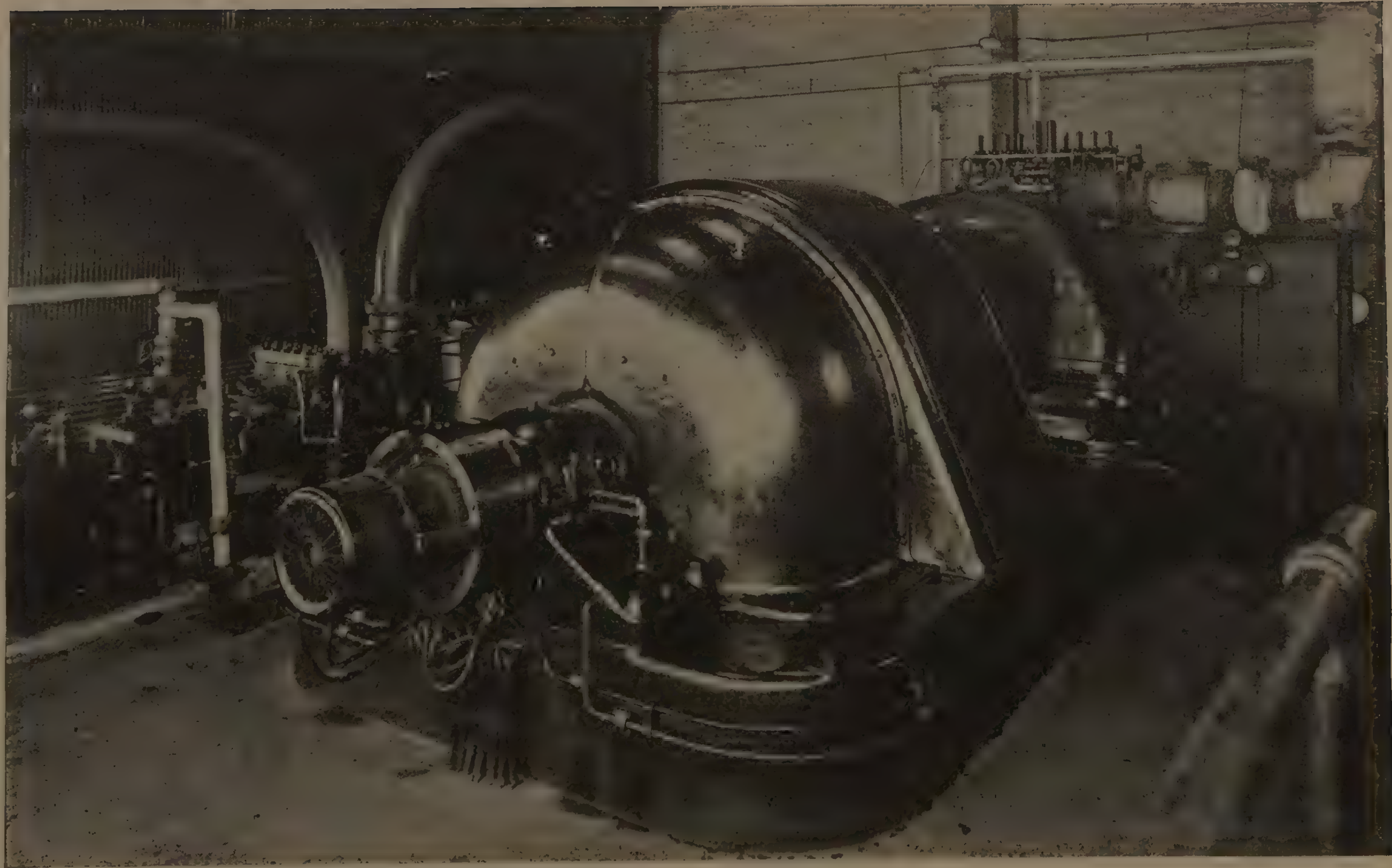


Fig. 23.—20,000 K.W. Steam Turbine, Jones and Laughlin Steel Co., Woodlawn, Pa.

POWER DISTRIBUTION IN K.W.

Blast Furnace, miscellaneous	850
Auxiliary Power, Exciter Losses, etc	320
Steel Mills	20,000
Total Power	21,170

Water rate for average load, 12 lbs. of steam per K.W. hour. Average steam consumption of turbo-generator, $12 \times 21{,}170 = 254{,}000$ lbs. per hour.

Turbo-Blowing Station

Five turbo-blowers are provided, one for each furnace and one spare. Allowing 3 per cent. for time out and stove losses, and using 57.9 cu. ft. of air per lb. of carbon, as previously deduced in Appendix A, we have as the capacity of the blowers $12{,}835 \times 2{,}000 \times 1.03 \times 57.9/730 \times 60 = 35{,}000$ cu. ft. per minute. Steam consumption of a high efficiency centrifugal compressor at average air pressure 15 lbs., 1.08 lbs. of steam per 100 cu. ft. of air. Total steam consumption of blowers $350 \times 1.08 \times 60 \times 4 = 90{,}800$ lbs. per hour.

Pumping Station for Steam Turbine Plant

WATER DISTRIBUTION—GALLONS PER MINUTE

Make-up and General Losses	600
Blast-Furnace Water	6,667
Turbo-Blower Water	1,200
Electric Station	500
Total Plant Water	8,967
Turbo-Generator Circulating Water	43,700
Turbo-Blower Circulating Water	12,400
Total Water	65,067

The circulating pumps are directly connected with the generators and blowers, and their costs are included therewith.

Boiler System for Turbine Plant

Boilers rated at 2,500 HP. each are used with economizers and feed-water heaters using exhaust steam from auxiliary apparatus.

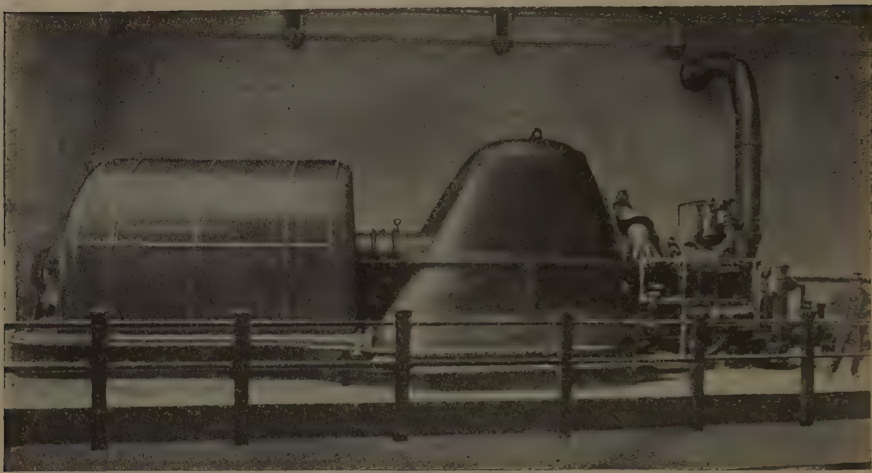


FIG. 24.—35,000 K.W. Steam Turbine, Boston Elevated Station.

FIG. 25.—Exterior of Station of Buffalo General Electric Co.

STEAM CONSUMPTION TABLE—LBS. PER HOUR

Total Non-condensing Steam Lost	12,800
Total Non-condensing Steam for Heating Feed Water	20,000
Turbo-Generators	254,000
Turbo-Blowers	90,800
Condensing Pumps	6,300
Total Steam	383,900

The temperature of feed water at entrance to economizer is 143° F., and 6 per cent. of the total heat of the gases is counted as available in the economizer. The main boilers raises the water from 233°, utilizing 75 per cent. of the heat in the gases, corresponding to 75 per cent. boiler efficiency. Total heat of the steam above 233° is 1,113 B.t.u. per lb. Total heat in the gas, $383{,}900 \times 1{,}113/.75 = 570{,}000{,}000$ B.t.u. per hour.

The steam-turbine plant, therefore, by these figures, requires more heat than the gas-engine plant.

The heat storage capacity in the boilers is considerably more than exists in the gas-engine plant, so that probably no more make-up coal will be needed than in the gas-engine plant. However, in order to make this comparison conservative, no consideration is given to this and enough coal is provided for, in addition to that provided for in the gas-engine plant, to make the apparent surplus or margin the same. This calls for an additional 62 million B.t.u. per hr., requiring coal costing $38,400 per year additional to that in the gas engine plant.

HEAT BALANCE FOR COMPLETE STEAM-TURBINE PLANT

	Millions B.t.u. per hour	Prev. value of Gas Plant
Pumps, Generators and Blowers	570	508
Stoves	323	323
Margin	245	245
Total	1,138	
Deduct Heat from Coal	62	
Heat from Gas	1,076	1,076

FIG. 26.—Interior of Station of Buffalo General Electric Co., Three turbines are installed and one is on order.

The costs of the complete plant are given in the second column in Table 1 of the main body of the paper and need not be here repeated.

APPENDIX E

Segregated Gas Electric Station

In order to enable a better comparison to be made of the electric stations in the steam and gas plants, all of the items in each case pertaining directly to the electric station are brought together. This, therefore, provides an electric station using gas-engine-driven generators fed by blast-furnace gas and including the necessary gas washing station and pumping station to supply the exact amount of gas and water for the gas electric station only. In the complete plant, as already mentioned, there were boilers for supplying the amount of steam regularly needed about the plant and for reserves for emergencies. That fraction of these boilers which is proportionate to the amount of gas used in the electric station is herein included in the cost of the gas electric station. This is necessary to give a station which will supply the requisite amount of electric power in any emergency.

Segregated Steam-Turbine Electric Station

In the same way as the gas-engine electric station was segregated, we segregate the steam-turbine electric station by including that fraction of the boilers and auxiliaries which belongs directly to the electric station.

President Gary: Copies of Mr. Rice's paper in pamphlet form, with all illustrations, can be had in the foyer at the entrance to the hall. There will now be a discussion of this last paper by Dr. David S. Jacobus of New York.

RECENT INSTALLATIONS OF LARGE TURBO-GENERATORS

Discussion by David S. Jacobus

Advisory Engineer, Babcock & Wilcox Company, New York City

Mr. Rice gives data respecting the development of large steam turbine practice but he does not refer to those who were pioneers in the field. A history of the sort is vitalized by including the human element, and I will therefore refer to some of those who took part, especially in connection with the development of steam turbines built by the Company with which Mr. Rice is connected, without attempting to give a complete record.

In the early days after the De Laval turbine had been brought to a successful form for small units running at high speeds, when many small units of various types were being experimented with, it fell to my lot to make a number of tests of small turbines. During this period Professor Denton, with whom I was associated, tested and made a study of a turbine designed by Mr. Curtis and reported that there were great possibilities for the development of large size units. Curtis' design was later taken up and successfully developed by the General Electric Company. It takes more than ideas to attain success in a case of the sort—it requires enthusiasm and nerve. I have often said that there is one who deserves unqualified credit for his work in the early days of the art, and this is Mr. W. L. R. Emmet, who was truly, as I recollect someone said at the time, a "boss optimist." Mr. Emmet believed in large steam turbines and believed so strongly that they would eventually displace piston engines that he risked much in advocating the building of the first large units, and it was his energy and push, backed by the vast amount of work done by others in his organization, that led to what finally resulted in the large steam turbines they are turning out to-day.

Mr. Rice says nothing of his own connection with this

development. At the time Mr. Rice entered the field the large steam turbine industry was in its infancy. Mr. Rice, through his experience in designing and building piston engines, was particularly fitted for the problems at hand, and as we all know, he has taken an active part in bringing the turbines to their present stage of perfection.

There are others who should be remembered in connection with the early development aside from those who took part in the actual construction of the turbines. It is not alone the designing engineer who takes a risk in launching a new enterprise; it is the engineer who is bold enough to try out the idea in actual service. Mr. Samuel Insull and Mr. Frederick Sargent were responsible for the installation of the first large size units mentioned by Mr. Rice, which were installed at the Commonwealth Edison Company of Chicago. The first large unit was a commercial success, irrespective of the fact pointed out by Mr. Rice that the steam consumption of an up-to-date steam turbine for a given electrical output is about one-half that required for this first unit. The co-operation of Mr. Insull and Mr. Sargent had a most important bearing on the remarkable progress that was made.

Mr. Rice's comparison of the results obtainable with large steam turbines and gas engines is a most interesting one. He shows that the thermal efficiencies of the two types of prime movers will be about the same for the power plant considered, where blast furnace gas is used for fuel, together with coal which is used in small amounts during occasional deficiencies of gas supply. When it comes to figuring the total charge for the plant per year, the balance is strikingly in favor of the steam turbine.

Mr. Rice states that by using the most modern equipment of boilers, superheaters and economizers, with gas which is passed through primary washers, an efficiency of 81 per cent. can be obtained. This figure may be reached with the proper equipment and the best sort of operation for a continuous load.

To obtain the best efficiencies with blast furnace gas there must be but little excess air supplied for combustion and the gas must be completely burned before the products of

combustion pass upward between the boiler tubes. To accomplish this there must be a sufficient furnace volume so disposed that there will be a proper path of travel for the flames, and the gas burners must be arranged to give the proper proportions of air and gas and the proper mingling of the air and gas. Recent developments with burners arranged so as to bring the pressure of the gas up to the outlet and so designed as to give an intimate mixture of the air and gas before entering the furnace have shown that higher furnace temperatures can be maintained than in the older practice and that the gas can be burned with a shorter flame than in certain of the older forms of gas burners. Higher furnace temperatures and the ability to burn the gas within a given furnace volume and the proper design of the boiler and its economizer makes it possible to obtain the efficiency given by Mr. Rice.

Mr. Rice deals with the possibilities of future development showing that an increase in economy can be secured through an increase in the steam pressure and the steam temperature and by paying attention to certain features of economizer operation. As time goes on undoubtedly the trend of progress will be in this direction, as the increase in the cost of fuel will make it possible to install more elaborate and expensive systems than those which now give the best commercial returns.

In the comparisons made in the paper the gas engine plant includes a reserve steam plant for carrying a portion of the load in case of emergencies. It would be interesting from a thermodynamic standpoint to compare the efficiency obtainable from the best gas engine plant with no steam reserve plant with that obtainable from the best modern steam turbine plant, the efficiencies being based on the heat in the gas used by the gas engine and on the heat in the coal or gas used by the steam turbine plant.* It would also be interesting to make a comparison on the basis of the heat of combustion of coal, the coal in one case being gasified in producers and the gas supplied to the gas engines, and in the other

* This has been done in the revision.

burned under the boilers. Such a comparison would not be a commercial one, as all fixed and operating charges would be eliminated, and further it would not form the basis of a fair comparison as the reserve steam plant is necessary to secure the same approximate degree of reliability for the gas engine plant as for the steam turbine plant, and the fuel required for the reserve steam plant should be included. The comparison nevertheless would give interesting data respecting the thermodynamic possibilities apart from reliability and fixed charges. It would appear that the results will indicate a somewhat greater coal consumption for a gas engine plant where the coal is gasified in producers than for a steam turbine plant, which is contrary to the ideas of many. It would add to the value of the paper if figures could be given by Mr. Rice to cover these cases.

Mr. Rice speaks of combined gas engine and steam turbine plants, pointing out that a steam turbine plant operated by the waste heat from a gas engine involves such a large expense in comparison with the increase of power as to make it unattractive under existing conditions. Should the cost of fuel be great enough a plant of the sort might be commercially practicable, but would seem that this will not be the case for a long time to come.

In the gas engine we obtain high efficiencies at the high temperature end of the cycle but are unable to utilize the low temperature end. In the steam turbine with modern condensing apparatus the low temperature end of the cycle is utilized to the fullest extent. It would therefore appear that there are great possibilities in combining the two. On working out an actual case it will be found that the work of the steam turbine would be comparatively small, amounting to, say, 10 per cent. of that of the gas engine, and it can be seen that the large amount of additional expense and complication involved would offset the saving in the cost of fuel unless the fuel is comparatively expensive.

Time and time again those of inventive minds have proposed new cycles for the production of power. In most cases these have been impractical, or if promising from a thermodynamic standpoint, have not been so commercially.

Mr. Emmet, who has done so much for the steam turbine, is, as most of you no doubt know, working on the development of a cycle where the work at the high temperature end is done by a turbine driven by the vapor of mercury and the work at the low pressure end is done by a steam turbine. This combination promises as high or even higher efficiencies than are obtainable through the combination of a gas engine and a steam turbine plant. It is eminently fitting that a man who has done so much in the development of the steam turbine should lend his energies to the development of a system of the sort.

It behooves us to look into the future in our endeavors to improve. Should we develop highly economical systems which are not immediately adopted our work is not in vain; we will be pointing out a way for those who will succeed us, who will have to go much more seriously than we do into the great problem of saving and conservation. (Applause.)

President Gary: We will have the pleasure of hearing Mr. Alex Dow, President of the Detroit Edison Company, through Prof. C. R. Hershfield, who is to read the paper.

Prof. Hershfield: I am presenting this material for Mr. Dow of the Detroit Edison Company, who unfortunately is unable to be here to present it himself. (Reads paper.)

RECENT INSTALLATIONS OF LARGE TURBO-GENERATORS

DISCUSSION BY ALEX DOW

President, The Detroit Edison Company, Detroit, Michigan.

The most useful response which I can make to the invitation to join in this discussion is to give you, first, some personal opinions based on thirteen years' knowledge of big turbines; and, second, the recent costs of a steam turbine station.

The first big turbine for which I was responsible was big in its day, although it would be considered small now. It was a 3,000 kilowatt vertical shaft 600-turn machine which went into commission in 1904. It was followed by three others of the same size and speed, and a fifth of the same size but higher speed and more economical. Following these, I have had in the service of The Detroit Edison Company four 9,000 kilowatt turbines, three of 14,000 kilowatts and one of 15,000 kilowatts, all of these being of the vertical type; and three 20,000 kilowatt machines of the horizontal type. We have under contract two turbines of 30,000 kilowatts and one of 45,000 kilowatts, the latter of which is now in transit from the factory.

A word as to the vertical shaft machine. It was pre-eminently a reliable turbine. Its reliability earned the affection of the men who had to live with it. Its inherent limitations are those of the vertical shaft, restraining it to a low rotative speed, which means (in a large turbine) either impracticably large discs or a sacrifice of economy. If some one would discover and apply a force acting horizontally as gravity acts vertically, the limitations would be removed and I believe the vertical shaft machine would continue to be the favorite of the central station operator.

My first large turbine used just twice as much steam per kilowatt-hour as does the latest one. Of course that first

one is out of service long ago. It was replaced by one of the 9,000 kilowatt turbines, and its original string of boilers, rearranged with different stokers and gas passages, serves the 9,000 kilowatt machine. The new turbine takes less steam and the boilers now make more steam. The improvement in the boiler room during the thirteen years is less spectacular but quite as useful as the improvement in the steam turbine. Unfortunately it is less known. I confirm Mr. Rice's statement that sustained boiler house efficiencies of 81 to 82 per cent. are possible, economizers being used. My justification for this statement is that we have year after year a boiler house efficiency of 76 per cent. all losses by banked fires included, etc., and made *without* economizers.

My observation is that turbine efficiency is too often cancelled, in the total operating costs, by badly designed and badly managed boiler houses, by poor condenser practice and by neglect of station heat balance—the usual fault of heat balance being an excessive or careless use of steam auxiliaries; the less frequent fault being making a fad of electric auxiliaries.

I arrange the conditions of power house design for economy, in order of importance, as follows:

1. Design your furnace and the gas passages of your boiler for the exact fuel you are going to use, or for an intelligent compromise among the different fuels which you may be compelled to use at one time or another.

2. Design the condenser system so as to utilize the full possibilities of high expansion which characterize the steam turbine but without over-cooling the condensate.

3. Buy a good steam turbine—remembering that it is possible to refine turbine design, in reaching for thermal efficiency, beyond the point of mechanical reliability.

4. Make your heat transfer as nearly as possible a closed cycle. This requires that you consider condensate temperature, make-up water, auxiliary power, station uses of energy, furnace draft and economizers, as one all together problem, and not as several separate problems to be left separately to the purchasing agent or to the "catalogue engineer."

The three tables which follow show our operating cost figures for the Connors Creek Station which went into regular service in June, 1915, with one 20,000 kilowatt turbine, followed presently by a second, and which put its third 20,000 kilowatt turbine into commission in March, 1917. It should be noted that the output from Connors Creek has been limited during the twenty-one months by transmission conditions. That is to say, to increase the output would have involved electric transmission or distribution losses external to the station, and that, therefore, the turbines have not ordinarily been loaded beyond three-quarters rating. The difference between the July to June twelve months (Table 1) and the January to December twelve months (Table 2) is due to the disturbance of coal supplies and costs in the last weeks of 1916. The same cause, together with the

TABLE 1

CONNORS CREEK POWER HOUSE.

PRODUCTION EXPENSE

12 Months Ending June 30, 1916.

Production	Total Expense	Expense per K.w.h.
Operation:		
Superintendence	$16,841.40	0.013¢
Wages	54,308.36	.043
Fuel	197,554.76	.158
Water	10.00	....
Lubricants	1,416.60	.001
Station Supplies and Expense	5,562.85	.005
Maintenance:		
Station Buildings	7,786.96	0.006¢
Steam Equipment	23,826.70	.019
Electrical Equipment	3,299.80	.003
Total	$310,607.43	0.248¢

K.w.h. Output	125,158,800
Maximum Demand (30 Minutes)	35,000
Average Load	14,300
Load Factor	.409
Coal per K.w.h.—Pounds	1.44
B.t.u. per K.w.h	19,700

increased use of heat in the buildings during the winter months, has affected the three months' costs, January to March, 1917 (Table 3). The difference between 19,700 heat units per net kilowatt-hour of output under normal conditions and 20,300 in the three-months period is 600 heat units of which 400 should be charged to disturbance of normal furnace operation by the use of unusual qualities of fuel. It takes time for the best of firemen to discover how to deal with a different coal fed without notice into his stokers. The remaining 200 heat units represents the difference between the midwinter radiation losses and the average for twelve months. A midsummer period for the same station shows 19,200 heat units.

TABLE 2

CONNORS CREEK POWER HOUSE

PRODUCTION EXPENSE

12 Months Ending December 31, 1916.

Production	Total Expense	Expense per K.w.h.
Operation:		
Superintendence	$20,521.67	0.013¢
Wages	68,477.62	.042
Fuel	282,135.47	.174
Water	10.00	....
Lubricants	1.055.23	.001
Station Supplies and Expense	10,037.92	.006
Maintenance:		
Station Buildings	$11,711.94	0.007¢
Steam Equipment	26,670.32	.016
Electrical Equipment	4,394.92	.003
Total	$425,015.09	0.262¢
K.w.h. Output	162,117,600	
Maximum Demand (30 Minutes)	36,000	
Average Load	18,500	
Load Factor	.514	
Coal per K.w.h. —Pounds	1.45	
B.t.u. per K.w.h	19,800	

(Hourly wage and price of coal per ton increased over July, 1915, to June, 1916, figures).

Let it be noted that the Connors Creek figures are for current actually metered out at the transmission voltage of 23,000 to 25,000 volts. They should not be compared with figures of current generated, whereof part is used for station purposes.

Let it be noted also that these figures represent a design of the years 1913 and 1914, and a balance between investment costs and operating costs based upon fuel of 13,500 heat units costing $2.40 per short ton. Were we designing to-day for fuel at $5.00—which seems to be the probability—we would buy turbines of still higher rotative speed, which would require about 9 per cent. less steam than our Connors Creek turbines, and which would be *nearly* as reliable; we

TABLE 3

CONNORS CREEK POWER HOUSE

PRODUCTION EXPENSE

3 Months Ending March 31, 1917.

Production	Total Expense	Expense per K.w.h.
Operation:		
Superintendence	$4,955.84	0.009¢
Wages	27,460.64	.050
Fuel	144,735.71	.264
Water	....	....
Lubricants	543.43	.001
Station Supplies and Expense	2,789.67	.005
Maintenance:		
Station Buildings	$6,972.03	0.013¢
Steam Equipment	8,681.11	.016
Electrical Equipment	870.12	.002
Total	$197,008.55	0.360¢
K.w.h. Output	54,654,900	
Maximum Demand (30 Minutes)	45,000	
Average Load	25,300	
Load Factor	.562	
Coal per K.w.h.—Pounds	1.56	
B.t.u. per K.w.h.	20,300	

(Hourly wage and price of coal per ton increased over January, 1916, to December, 1916, figures).

would install economizers, for which we have room, but which we have not heretofore thought desirable, and thereby bring our maintained boiler room efficiency up from 76 per cent. to, say, 81 per cent.; and we would make certain other refinements in our heat balance which might save 1 per cent. of our total fuel. The result of these changes would be a reduction from a normal use of 19,700 heat units per kilowatt-hour to something like 17,000 per kilowatt-hour of net output. (Applause.)

President Gary: Is there any further discussion? (Pause.) If not, we shall now have a paper on The Manufacture of Steel Castings by President Lamont of the American Steel Foundries, Chicago.

THE MANUFACTURE OF STEEL CASTINGS

Robert P. Lamont

President, American Steel Foundries, Chicago, Illinois

In the Proceedings of the American Iron and Steel Association (as it was then called) for the year 1883 it is stated that "included in the production of open-hearth steel ingots in 1883 are 1,684 net tons of steel castings made directly from the open-hearth furnaces. The production of steel castings is rapidly increasing in this country." From year to year since then the annual figures have been given, but as far as we can find there have been no papers on the subject, so perhaps to begin with a brief statement outlining the history of the industry may not be out of place. In so far as we could find, no one in this country has undertaken to record its early history or to keep any record of its development. A fairly complete search through several scientific libraries, and the available literature on the subject, has disclosed some facts which may be of general interest to the members of this Institute.

Cast Steel and Steel Castings

Every ton of steel produced by present methods may properly be called cast steel, but only a comparatively small percentage of this steel in its final form may be correctly described or referred to as steel castings. There would seem to be a rather small margin of difference between pouring the molten metal into an ingot mold preparatory to its being rolled or forged, and pouring the same metal into a mold in which it takes its final form and shape. Looking at it now, it doesn't seem as if it should require any great inventive skill to step from one process to the other. In principle it is a simple matter, but the practical difficulties were great and the development of the cast steel industry was correspondingly slow.

Because of this rather narrow line between the first stage of ordinary steel making and what is in a sense the final stage of making steel castings, it is difficult to point out any definite place and date at which it can be said with certainty, "Here is where the making of steel castings began." In the large volume of literature on the early history of steel making there are practically no references to steel castings. The expression "cast steel" is frequently used, but it refers in every case to the pouring of the metal into ingot molds.

The probabilities are that the first castings were of simple form—such as could be produced in metal molds, and were no more difficult to make than ingots. As more complicated shapes were attempted, the necessity developed for a different kind of mold. The art, if it may be so called, was no doubt a gradual development, and no single name stands out prominently as the inventor of steel castings as now produced.

Developing the Industry in Europe

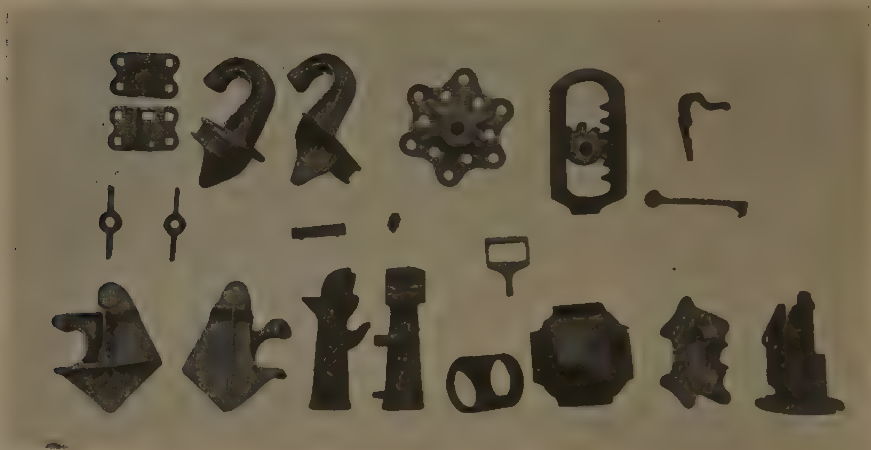
However, there seems to be no question but that the credit for making the first steel casting belongs to Germany. In the report of our Federal Commissioner, Mr. William P. Blake, to the Vienna Exposition of 1873, in describing the exhibit of the Bochum Steel Works in Westphalia, this statement is made: "One of the special operations in this works is the casting of steel in molds, after the invention of the technical director of the works, Mr. Jacob Mayer." Although the process was not patented in the country, it remained for ten years the exclusive property of the company and of those works in France and England which had obtained the rights to manufacture. The report continues: "Another specialty of these works is the manufacture of cast steel bells. We have not space to detail all of the advantages and virtues of cast steel bells. Their manufacture dates from 1851. As early as 1855, at the Paris Exposition, the bells of the company attracted general attention. The surprise of the inspectors at this new steel

product, indeed the doubt as to the possibility of working steel in this way, was so great that they desired an inquiry to be made to ascertain whether these bells were really steel, as was represented, or whether they were made of cast iron. The result of the inquiry was the bestowal of the Great Gold Medal by the jury of the Exposition upon the following grounds: "The exhibited bells are characterized by perfection of performance, and a very clear unmixed tone, which is as clear as that of the ordinary bronze bells." As a consequence the jury came to the conclusion that the Bochum Company, by its method of molding and pouring steel, had not only superseded bronze as the material for bells but had given a new direction to the manufacture of large forged and rolled pieces of machinery. The bells were cheap, costing about one-half as much as bronze bells; they were heavy, and since 1855 their manufacture had greatly and rapidly increased. In the year 1858 a test proved "that it is impossible with human power to crack one of these steel bells with heavy sledge hammers."

The steel in these early castings was melted in crucibles and cast in metal molds. Jacob Mayer is the only individual name mentioned in this reference to the early history of steel castings, but it is not clear from the report whether the technical director in 1873 was the originator of the industry which apparently started in 1851, or whether he carried the process beyond the metal mold stage.

Immediately after the Paris Exposition of 1867 the Terre Noire Works of France began a series of experiments to produce a metal to meet the requirements for projectiles for navy guns. They used a Siemens-Martin furnace, and the subject was gone into thoroughly from a metallurgical standpoint, probably for the first time. A number of irons were tried with the addition of a certain amount of steel scrap before casting. The results showed that the addition of scrap improved the iron, but the variations in the breaking points of the steel were found to correspond with the amounts of silicon it contained. If the addition of steel scrap was pushed beyond a certain limit, blow-holes began to appear. Experiments showed that projectiles made of this steel

would not stand up in test. It was determined that to obtain steel without blow-holes, a proportion of 11 per cent. to 12 per cent. of pig containing 3.5 per cent. to 4.0 per cent. of silicon should be added. This gave a hard metal and proved unsatisfactory. The metal was pasty, ran badly, and did not stand forging well. It was found necessary to add a certain amount of manganese in the initial bath, which made the slag sufficiently fluid to separate from the metal. It was of greatest importance to keep the oxidation as low as possible, and the process finally resolved itself to the employment of manganese and silicon in definite proportions and at regulated times. The metal was tapped directly into the molds, there being two tap holes, side by side, running into one spout fitted with two nozzles.



Miscellaneous Steel Castings, weighing from a few ounces to 10 pounds each.

About this time, that is to say, about 1870, this company was producing all sorts of industrial castings, such as cast steel car wheels, frogs, roll-pinions, etc. It was not until 1875 that the Terre Noire Company produced a cast steel shell which would go unharmed through armor plate. By 1879 this works was producing two hundred tons of steel castings per month, about half of which consisted of projectiles for the French Government. The elastic limit of the

steel was about from sixteen to twenty-eight tons per square inch, with an elongation of from two and one-half to fifteen per cent.

At the Paris Exposition of 1878 the Hadfield Steel Foundry Company of England exhibited double spur wheels, railway crossings, wheels, pulleys, hydraulic cylinders, etc.

Early Development in the United States.

In the United States a few attempts were made during the Civil War to produce small field pieces of cast steel. A number of steel works are reported to have made steel castings for their own use during this period. The best information indicates that the first steel castings produced in this country, which were of value commercially, were made in July, 1867, by the Wm. Butcher Steel Works, which afterwards became the Midvale Steel Works. These were crossing frogs for the Philadelphia & Reading Railway and were made of crucible steel. This was before the adoption of silicon for solidifying steel, and the castings were much honeycombed in all parts, except the wearing surfaces, which were solid and very smooth. The excessive sponginess of these castings, however, prevented their general use, although Mr. W. F. Durfee, who was Superintendent in 1871, stated that they made quite a number of steel castings for reversible frogs, which weighed from 250 to 900 pounds.

In 1870 William Hainsworth of Pittsburgh erected a small furnace having two crucibles, and made castings for the cutting parts of agricultural implements. He kept on experimenting until his capital was nearly exhausted, but in March, 1871, he incorporated a company and erected a plant at Pittsburgh. This was known as the Pittsburgh Steel Casting Company, and was one of the first steel foundries in the country. In making his molds Mr. Hainsworth used ground coke mixed with ground plumbago crucibles, German clay, and all tempered with glue water. On this mixture he took out a patent.

In the latter part of 1874 Mr. Hainsworth had an open-hearth furnace constructed, which in 1875 was used in

making steel castings. These, I believe, were the first steel castings from an open-hearth furnace in this country.

On April 28, 1876, the Midvale Steel Company made two hammer dies of open-hearth cast steel, and the next month made a hammer head weighing 2,535 pounds. The appearance of these castings was against them, as the surfaces were imperfect and the sand adhered to them in large quantities. There was also considerable trouble caused by piping and cracking.

The first use of the Bessemer process for making steel castings is said to have been made by Mr. Hainsworth in 1881.

Hawse Pipe for Battleship *Mississippi*. Weight, 12,930 Pounds.

One writer during this period states that castings of plain section, weighing 100 pounds, sold as high as twenty to twenty-five cents per pound. However, from 1867 to 1880 the output of steel castings was very small.

A number of other plants now (in the early 80's) commenced producing steel castings. One of the concerns which achieved unusual success was Mackintosh, Hemphill & Company, of Pittsburgh, better known as the "Old Fort Pitt Foundry." They began the manufacture of steel castings by the Terre Noire process in 1881 and 1882.

In 1882 the Solid Steel Casting Company was founded by J. K. Bole, S. T. Wellman, T. R. Morgan, Sr., and S. J. Williams. The plant was erected at Alliance, Ohio, and the first steel was made in a three and one-half ton open-hearth furnace. This is now the Alliance Plant of the American Steel Foundries.

Another plant built about 1882 was the Standard Steel Castings Company of Thurlow, Pennsylvania. This firm first made castings by the crucible process, but installed an open-hearth furnace in September, 1884. They were unusually successful with large work, furnishing many steel castings for government vessels. This is now the Thurlow Plant of the American Steel Foundries, and still turns out many castings for battleships, cruisers, and other large vessels. At the present time it has just finished all of the castings for superdreadnaughts *Pennsylvania* and *Arizona*, and has on hand unfilled orders for castings for nine battleships and cruisers, and eleven destroyers.

About this time, i.e., about 1882, the business began to develop more rapidly, and in 1885 there were quite a number of successful plants in operation, among which may be mentioned: (1) Solid Steel Casting Company, Alliance, Ohio; (2) I. G. Johnston & Company, Spuyten Duyvil, New York; (3) S. G. Flagg & Company, Philadelphia, Pennsylvania; (4) Chester Steel Castings Company, Chester, Pennsylvania; (5) Pittsburgh Steel Casting Company, Pittsburgh, Pennsylvania; (6) Mackintosh, Hemphill & Company, Pittsburgh, Pennsylvania; (7) Cowing Steel Castings Company, Cleveland, Ohio; (8) Eureka Steel Casting Company, Chester, Pennsylvania; (9) Standard Steel Casting Company, Chester, Pennsylvania.

Early Difficulties with Molds

Much difficulty was experienced with molding sand in these early days, and it was claimed that the Midvale people, for instance, lost money regularly on steel castings for years while trying one mixture after another. At first a molding mixture of ground brick, ground pots and fire clay was used. The next step was to leave the ground pots out of the mixture, and to wash the mold with finely ground clay fire brick.

Cast Steel Rudder Frame for the Battleship *Mississippi*. Weight, 50,500 Pounds.

This made a marked improvement in the general appearance of the castings. However, the mold became hard, and intricate castings could not be made on account of cracks. Next, a mixture of sand and flour was tried, but there was a tendency for the flour to burn out. By 1887 a suitable mixture of sand and molasses had been obtained. George Cowing, of Cleveland, is credited with first making a mold for steel castings composed of nearly pure silica, glue water and molasses. At this time all molds were baked in ovens, but efforts were being made towards perfecting a process to allow the casting of small shapes in green sand. In general, castings produced about this time were anything but satisfactory. In large castings particularly the earlier molds would burn onto the metal, or the metal would penetrate the molds in a spongy mass, requiring a great deal of labor and expense for chipping. Reference is made by writers in the 80's to pinions weighing 13,000 pounds requiring two weeks to clean, and on which there was a piece-work price of $2.00 per tooth. It must be remembered that at this time there were no pneumatic hammers. These first castings were hard, brittle, and not homogeneous. They were so full of blow-holes that one writer defined the ordinary steel casting as a rough chunk composed of about equal parts of steel and holes. The shrinkage problem was more difficult than with gray iron castings, and it took years of patient effort to overcome the difficulties involved. In an article of the *Iron Age* of October 1, 1883, P. G. Salom, President of the Standard Steel Casting Company of Thurlow, Pennsylvania, said: "It is almost impossible to make certain thin complicated castings of steel on account of shrinkage troubles."

Government Encouragement

Although the field for steel castings kept widening, they were not giving universal satisfaction. Their appearance was against them. Very few of the foundries had their own laboratories. In going over the history of the business during this period—1880, say to 1890—one gets the impression that the castings were pushed on the market before the art

was fully developed, and with the result that steel castings fell into a certain disfavor which seemed to retard the progress of the industry for several years.

Our own government was one of the first to experiment with and make extensive use of steel castings in this country, especially for battleships. Between 1880 and 1890 the English founders were successfully turning out stern frames, rudders and stem pieces. Our own people apparently had not acquired the same skill, for in his report for 1890 Engineer-in-Chief Melville, of the Navy Department, stated, "I am obliged to report we are having a most discouraging experience with steel castings." He further stated that when the first new vessels were being built, the steel founders claimed that they could cast anything in steel that could be cast in iron, but that there was now (1890) a wide diversity among steel founders as to what shapes were practicable for casting in steel.

In 1887 Congress passed an Act calling for the manufacture of three cast steel, six-inch, breech-loading rifles, to be made by the crucible, open-hearth or Bessemer processes, and to weigh approximately 11,000 pounds each. Only two were supplied: one of Bessemer steel and one of open-hearth steel. In the tests the Bessemer gun failed at the second round. The open-hearth steel rifle was cast by the American Steel Casting Company of Thurlow, Pennsylvania, and was not submitted to any mechanical treatment after casting. Although it stood the statutory test of ten rounds under service charge, there was a slight increase in the diameter of the barrel after the tests and the government rejected the gun. Failure of these tests caused a good deal of comment at the time and discouraged further efforts along this line.

Steel Castings for Railroads

Although at the present time a very large percentage of all steel castings produced in the country are used by the railroads, it is interesting to know that as late as 1885 very few were being used on cars or locomotives. At a meeting in Washington this year, the Railway Master Mechanics'

Cast Steel Stern Post for Battleship *California*. Weight, 44,540 Pounds.

Association devoted some time to a discussion of their use. A number of the members were using steel castings for cross heads only, and on a few roads driving boxes, link hangers, eccentrics and rocker arms, in addition, were being made of cast steel. The Pennsylvania Railroad specifications in 1888 for steel castings required tensile strength of 70,000 pounds and an elongation of fifteen per cent. in two inches.

At the Chicago Exposition in 1893 there were exhibited by Krupp some steel castings which at that time were considered very remarkable, among them being a cast steel frame for a Pennsylvania Railroad locomotive. At a meeting of the American Society of Mechanical Engineers at the time, doubt was expressed as to whether any American steel foundry could make such a casting. A contrary opinion was expressed to the effect that possibly three or four steel foundries in this country could make such a casting, but that probably several castings would be lost before a successful one could be produced. Stimulated possibly by this exhibit and by the growing demand, American manufacturers soon demonstrated their ability to make these frames, for five years later they were being generally used. These first frames were light and of simple design, as compared with those now made every day as a matter of ordinary routine. At the present time frames are not infrequently thirty-four feet long, and weigh up to 14,000 pounds. The percentage of loss in a good foundry does not exceed four.

Development During Recent Years

During the past twenty years the development of the steel-casting industry has been steady and rapid, although, of course, the production has had ups and downs following general business conditions. Beginning with the nominal production of 1,684 tons in 1883, by 1897 the production had increased to approximately 100,000 tons. Today there are about two hundred steel foundries in the country, with a total rated capacity of approximately 2,000,000 tons, though the actual production for last year was probably about 1,500,000 tons. The exact figures are not yet available.

Cast Steel Engine Frame. Weight, 16,856 Pounds.

The production curve for steel castings for the past twenty years plotted alongside of one showing, for instance, the ingot production of the country shows a considerably more rapid rate of increase for steel castings.

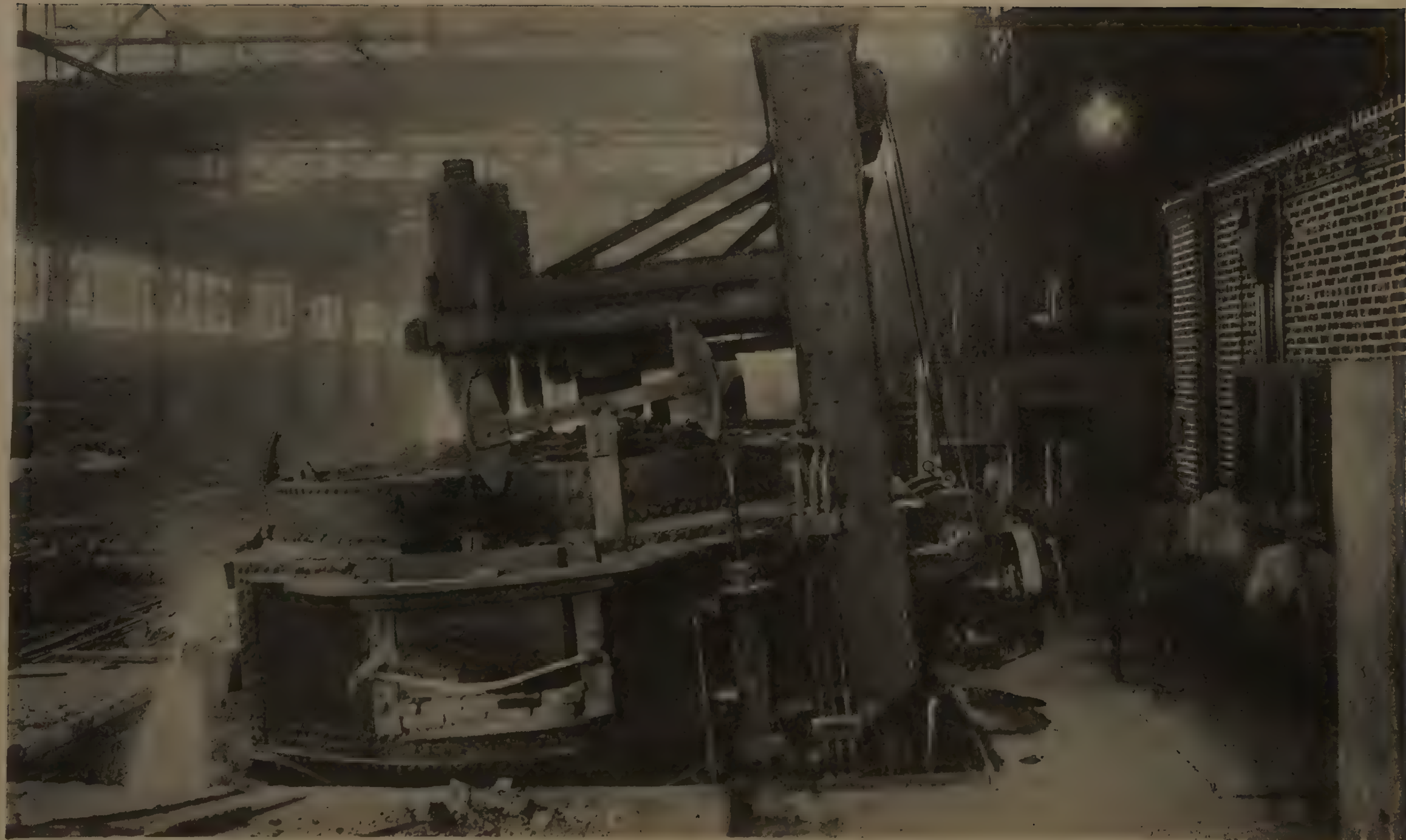
While the product cannot even yet be said to be perfect, a great deal of careful, painstaking, intelligent study has been given to overcoming the difficulties in the processes, and it can at least be said that steel castings have to a large extent lived down the somewhat uncertain reputation earned during the first development period.

The Quebec Bridge Disaster.

In this connection I think it not out of place to refer to the disaster to the center span of the great Quebec bridge on September 11, last. Practically all of the early newspaper accounts, and even a good many of the technical journals which were published before a thorough investigation was made, gave as the cause of the accident the "failure of a steel casting." One of the railway journals went so far as to say, "It was the well-known treachery of a steel casting." As many who read the first accounts may not have followed the matter further, I would like to read a short extract from an editorial in the *Engineering News* of October 5, written after there had been ample time for a complete investigation:

The rocker casting that broke was too weak by its very design. It was unsafe. So also were its three brother rockers. Because one of the four broke it has been called defective—it was rendered weaker than the others by some internal condition. But calling this one rocker defective does not mean that the other three were safe and adequate.

The stress analysis presented on another page brings out the plain hard fact that the rockers at the time of failure were under very high stress. Figuring on neither the most favorable nor the most unfavorable basis of calculation, it is certain that the stress was higher than would be considered safe even in the very dependable rolled steel members of bridges. It was higher than the stress which the engineers of the Quebec bridge permitted in the rolled steel bars of the great chains by which the span was being lifted,



Six-ton Heroult Electric Furnace.

although these had been tested so thoroughly that their large factor of safety was amply established.

Moreover, the engineers knowingly allowed higher stress in the rocker castings than in the chains, although (by test) the chains could not fail until 60,000-lb. stress was passed, while the ultimate strength of the rockers was entirely problematical. They allowed the high stress to be applied as a tensile stress to a thin projecting edge of a casting, where, if anywhere, a crack might have its origin. Even worse, the thin edge carried its highest stress at the root of a reëntrant right-angle corner of the casting, where the fillet had been notched to make a carefully fitted seat for a centering plate. This edge, also, was the top of the casting, where impurities often gather.

It was a clear case of a badly designed casting.

Merits of Different Methods.

Of the approximately two million tons capacity of steel castings in the country to-day about fifty-two per cent. is for basic and forty-eight per cent. acid steel. Almost ninety per cent. is produced in open-hearth furnaces; eight per cent. in convertors; and the balance in electric furnaces and crucibles. We have no accurate information as to the division of tonnage between dry and green sand molds, but the figures are probably not far from sixty per cent. green sand and forty per cent. dry sand.

A comparatively recent important development in the industry was the coming in of the electric furnace. If it has not already done so, it will no doubt soon entirely replace crucibles and convertors as a means of melting. Steel melted in the electric furnace can be brought to almost any state of purity desired, and a very high temperature can be secured. The electric furnace will produce steel of as good quality and at lower cost than the crucible, assuming, of course, a reasonable price for current and sufficient demand to take the output of the furnace.

It is not necessary here to describe the difference between the acid and basic methods, but it might be well to say that practically all machine castings—castings requiring any machine finish—are made of acid steel, while all mis-

cellaneous car castings, such as bolsters, side frames, center-plates, couplers, etc., which do not require machining, are made of basic steel and in green sand molds.

Acid steel castings, particularly if made in dry sand molds, present, as a rule, a better external surface and are freer from pinholes and surface defects. When you get below the surface, however, a test of basic steel will show just as good physical properties as the acid steel. The production of acid as compared with basic steel is less complicated from a

Housing for Lukens Steel Company. Weight, 24,045 Pounds.

chemical standpoint, and is rather more generally susceptible of control in the matter of soundness or freedom from blow-holes. The fact that it takes about an hour, to pour an average heat into steel castings, means, of course, that the slag is in contact with the top of metal in the ladle just this length of time, and the *basic* slag takes up the silicon from the steel and in return gives up substantial amounts of phosphorus, with the result that the last metal to leave the ladle is inclined to be "wild," resulting in porous

castings, and sometimes a rather high percentage of phosphorus. This difficulty is not met in the acid steel.

There is, I think, a somewhat mistaken impression as to the difference in cost between acid and basic steels. At the present time low phosphorus pig, which is used in the acid process, is selling for about $75.00 per ton, and low phosphorus scrap $40.00 per ton, while basic pig is, say, $42.00 at Pittsburgh, and heavy melting scrap about $32.00. Taking into account simply the difference between these figures, apparently the acid steel would be very much more expensive than the basic. However, when account is taken of the fact that a much smaller percentage of pig is used in an acid heat than in a basic heat—that the melting time is considerably shorter, the melting loss less by about two and one-half per cent. of the metals charged, and the life of the furnace substantially longer—the difference in cost is not great. At the present time, taking all factors into account, I should say that in the Chicago territory, for instance, the difference in cost is not more than $2.00 per ton, in favor of the basic steel.

Dry Sand and Green Sand Molds

The so-called dry sand mold is made of a mixture of silica sand and fire clay, modified in some cases with small percentages of rosin, dextrine or flour. After the mold is finished it is dried in an oven, which is kept at a temperature of about 500 degrees Fahrenheit for from six hours to six days, depending upon the volume of sand to be dried. This drying process, of course, ties up a large amount of flask equipment, requires a great deal of fuel and extra handling, and adds at least $4.00 per ton to the cost of the castings over the green sand method. In the case of large, rangy castings, such as stems, stern posts and rudders for battleships, the molds have to be rammed, then split up into sections, which are dried separately, and finally fitted together on the dry floor before the casting is poured. Under ordinary conditions such a mold is in process of construction ten days to two weeks before it is ready for the metal.

Green sand is composed of silica sand and silicious fire clay, in the proportion of about one clay and ten sand, all

thoroughly bonded in a heavy sand mill. These molds can be filled immediately after they are prepared—in fact, the sooner, the better, for if they are allowed to stand unusually long, the cores take up considerable moisture, and in dry weather the sand mixture tends to lose its bond and disintegrate. The development of this green sand method of making castings gave a great impetus to the business, on account both of reduced cost and of smaller investment required in plant and equipment.

This matter of getting a proper molding mixture was the great difficulty confronting the early manufacturers of steel castings.

On account of the length of time it takes to pour an ordinary ladle of steel into castings, and because also many castings have thin sections, it is necessary to have a metal temperature at the time the heat is tapped of between 2,750 and 2,800 degrees Fahrenheit. The melting point of the mold is about 3,200 degrees Fahrenheit, so that the margin between the temperature of the steel and the melting point of the mold is rather narrow. As a matter of comparison, the pouring temperature of gray iron is from 2,200 to 2,300 degrees Fahrenheit, and of malleable iron from 2,300 to 2,400 degrees, which is well below the melting point of the mold, and the sand is not seriously injured; whereas, in a steel foundry the facing sand, so-called, which comes in contact with the hot metal a few times is practically destroyed, and can thereafter be used only for backing. If a good surface is required for castings, care must be taken in every case to see that only new sand is used where it comes in contact with the metal. In green sand work about 1,500 pounds of new sand is required per ton of castings, and in dry sand the average is a ton of sand to a ton of castings.

Obviating Cracks, Pipes and Blow-holes

The next great difficulty which confronted the manufacturer of steel castings was to avoid shrinkage cracks. The contraction of cast steel is about seven thirty-seconds of an inch per foot—practically double that of cast iron. To get an idea of what this means, a locomotive frame thirty-four

feet long, for instance, will shrink or contract six or seven inches in length in cooling from a liquid to a solid state, and provision, of course, must be made to allow this contraction to take place. A long, slender section of a casting, with flanges or projections at both ends, will invariably crack, and in extreme cases pull itself apart, unless the holding power of the mold against these flanges or projections is removed in time. It is important in the designing of steel castings to avoid, wherever possible, such a condition as this. It is equally important to avoid a sudden change from a heavy to a light section.

Another difficulty with the proper production of steel castings is the avoidance of pipes and shrinkage cavities. This can be done only by the use of risers or shrink heads of sufficient size and number and properly located. In extreme cases the weight of metal in these risers—which must, of course, be cut off—equals the weight of the casting itself, and the average of net production of castings probably is not over sixty-five per cent. of the metal charged. In green sand work, where the sections are thin and heavy risers not used, the yield may in some cases run somewhat over seventy-five per cent. The cost of cutting off these risers, and the fact that to produce a ton of castings requires from a ton and a half to two tons of metal, is a very large item in the cost of steel castings. Not infrequently these risers are necessarily located on a casting at points extremely difficult to reach with a cutting tool. In the last few years the use of gas cutting torches has greatly facilitated this work.

Another trouble which has long been difficult to overcome, the one which perhaps more than any other has been the cause of a good deal of the unfortunate reputation steel castings had in the earlier stages of the development of the business, is porosity—blow-holes, so-called. There are many causes for this condition, among the principal of which are: Improper composition of metal, wet sand, too much carbonaceous material in sand mixture, poorly ventilated cores, too rapid filling of the mold, improper gating. The truth is that the proper making of a steel casting calls for the coördination of a good many elements; if any

Stern Frame for Munson Steamship Line.

one is imperfect, the effect is sure to be seen in the casting. And the difficulty is that in the handling of certain of these elements, no rules can be laid down which will satisfactorily guide an inexperienced man. Skill based on long experience is apparently the only sure guide. Of course, the metal itself, up to the time it reaches the mold, is susceptible of pretty exact manipulation, but for the proper method of molding, and the location of gates and risers, there are apparently no rules that can be laid down.

Need of Annealing

Then, after the casting is all but finished, it must be annealed to relieve possible internal strains due to irregular shrinkage in the casting itself, and the different rates of cooling due to variations of section, etc. There has been a great deal of difference of opinion on this matter of annealing. Some makers have gone so far as to claim that it was not necessary. A paper could be written on this subject alone. Our experience is that annealing is necessary; certainly it is in the direction of safety, and there is no question but what it refines the carbon structure and increases the elastic limit of the steel. The proper annealing temperature depends upon the carbon content of the casting, and ranges from about 1,300 to 1,650 degrees Fahrenheit for carbons from .20 to .90. The only certain method of determining whether a casting has been properly annealed is by a microscopic examination of a test piece broken from the casting. The time taken in bringing the casting up to the proper temperature and the rate of cooling are both important factors in the final result.

So much for the mechanical and manufacturing features of the industry. The business history of the industry has been about the same as that of most industries. The early experimental and development stage was difficult and unprofitable. In course of time a few successful businesses were developed and made money. After that there was apparently a too rapid expansion of capacity, excessive competition and no profit. Then followed the usual dropping out of the weak and the building up of the strong companies.

During recent years, when general business conditions have been good, I think the industry as a whole has shown a fair margin of profit. Following policies and methods suggested and practiced by this Institute, the larger companies have been more inclined to work on a "live and let live" basis. We have been exchanging information as to methods, comparing costs, and undertaking in certain directions to adopt standard designs and specifications, all with the idea that by improving our methods and reducing our costs, we will broaden the field of the industry and make more work for us all. (Applause.)

President Gary: Discussion under the five-minute rule by Mr. R. P. Flintermann, of Detroit.

THE MANUFACTURE OF STEEL CASTINGS

DISCUSSION BY R. F. FLINTERMANN

President, Michigan Steel Casting Company, Detroit, Michigan.

We have listened with much interest to the history which the author outlined about the steel casting industry. There were a great many points which were new and unknown, even to those of us who are engaged in this particular industry. Not the least interesting to me was the fact that as far back as 1882 there was a company known as the Sound Steel Casting Company. I trust that they bore this name deservedly.

In reading over the paper, it struck me that the history was outlined very much from the point of view of the manufacturer of the large steel castings. It might, therefore, be interesting to say a word or two from the viewpoint of the maker of the small steel castings. By that I mean castings such as those we produce. Our average weight is in the vicinity of twenty pounds. The castings are largely truck castings, light machinery castings and tractor castings. They are usually on the outside of a truck, where the appearance must be good. They are machined on many of the surfaces, and, therefore, must be sound. These castings must be of a strength such that they could not be made of malleable iron; they are of a contour such that they cannot very well be made of forgings.

Now, we have made these castings in three different ways: first, by the crucible process; then, by the converter process; and lately by the electric furnace. I wish to take issue with the author, where he states that the electric furnace will produce steel of as good a quality as the crucible. I think crucible steel castings for a long time bore a halo, to which they were not entitled, this halo having descended to the crucible steel castings from the tool steel industry. It is our contention that steel castings of the best quality were not produced by the crucible process. First of all, the trade

demanded a casting with a .25 carbon content. It was difficult to maintain this content on account of the varying absorption of carbon from the crucible itself. The greatest difficulty, however, was the fact that the manufacturer could not maintain a very high manganese content In order to keep the manganese about .60 he had to add enough ferro-manganese to successfully meet the necessary requirements, with the result that his pot was very rapidly attacked, so that instead of obtaining three heats per pot he obtained

Manganese Steel Clutch Disc. (See page 107.)

only one heat per pot. In order to prolong the life of his crucible, the manufacturer reduced the amount of ferro-manganese addition, so that final metal contained only .40 to .45 manganese, which was too low. And necessarily the steel was not as completely deoxidized as it should have been. The physical results were not what the trade demanded.

The converter process gave us some better results. We could maintain a higher manganese content; but here also the lack of complete deoxidization was a great drawback, and we, desiring a higher quality, finally used the electric

furnace. We have a six-ton and a three-ton furnace, and the results have been very satisfactory. We started running them basic. On account of the difficulty of obtaining refractories, we were obliged to change to acid practice. The experience that we have had has been such that we would not go back to the basic. The process was developed; a close watch was kept on it, and we do not hesitate to say that we get just as good results physically from the acid as we had obtained from the basic.

Manganese Steel Clutch Disc. Another view.

But the one great advantage we find is that we have a complete elimination of slag, and this is very essential where you have castings which must be machined on so many of their surfaces. If this slag appears anywhere on these machined surfaces, it is a fault which condemns the casting.

We will shortly install another furnace which we will run basic, but we will use this in conjunction with the acid furnaces and will thus have a process which might be termed a reverse duplexing. The acid will be the last process. We aim to melt just a portion of our material in the basic, finishing in the acid furnaces. In this way we can use a cheaper stock in the basic furnace. We need not run our

basic furnace at so high a temperature, because the castings will not be poured directly from this furnace, and this will enable us to maintain our linings a longer time. The steel will be added to the acid furnaces in which we have already started our operation, and we will get the advantage of the acid operation last in this way, which we consider a very distinct advantage. We firmly believe that this reverse duplexing will come to be used in other processes, as for instance in the manufacture of tool steel.

In making our experiments, the slag was a very difficult thing to handle. We could not remove this slag by any of the schemes we used. It almost seemed to us as though at those high temperatures, which we had to have, the basic slag was actually in solution. The steel was apparently clean, but as the casting cooled this slag was removed or became separated from the steel itself and showed on some of the surfaces.

I might add just a word or two about other advantages that we have found. The author referred to the difficulties of shrinkage cracks. There is no question whatever that we have less trouble with shrinkage cracks with electric steel. We believe that this is due primarily to two things: possibly to a lower sulphur content, but probably to the fact that we have a product which is completely deoxidized. For some reason or other, probably the absence of impurities, the steel seems to have a much greater strength at higher temperatures than steel made by any other process. As a result, when the pull comes on the casting as it shortens it seems to have strength enough to withstand the pull and stays whole instead of cracking. But even so, we have to use a great many devices in order to help this matter out. We use chills, both externally and in the heavy bosses and heavy parts, and we have to dig the casting out. We have to use ties which afterwards have to be chipped off.

One of the most useful points about the electric steel is the fact that we can now make alloys successfully. We found the Bessemer converter very unsatisfactory for this purpose, but now with our steel thoroughly deoxidized we get the full value of any of the alloys which we use. We can count on a

definite analysis, and as a result the heat treatment which we give that steel produces the result which we are after, and does this consistently. We were unable to do this by either the crucible or converter process.

In closing I want to add just one point more. We are trying to develop the use of manganese steel in the pleasure car vehicle. You are all familiar with manganese steel and the uses to which it is put. We have lately made one or two parts, and I believe it is the first attempt to use manganese steel in the pleasure car. I refer to the clutch disc on one of our well known makes of cars. It is a rather difficult piece to make. It must have a perfectly hard surface in order that the sliding back and forth of the discs will not destroy the surface. It must have great strength, inasmuch as the entire thrust of the engine is taken up by this part. We were told that it could not be made in manganese steel, but we were game to try it, and it has come out successfully, and I believe will be used by the automobile makers. (See pages 104 and 105.)

There were a great many problems to work out. In the first place, there was the small tapering keyway; there were a number of small holes which had to be threaded. The great difficulty was to avoid having too much finish. On the ordinary steel casting one-eighth of an inch is allowed for finishing. This would be prohibitive in a grinding operation in a case of this kind. Not over one-sixteenth of an inch was allowed, and the piece had to be ground to dimensions which were not to vary over one one-thousandth of an inch. I do not believe that this can be done except with steel which has the right composition and the proper fluidity, because the piece is less than one-eighth of an inch thick at some points. And above all, it had to be clean steel—no slag.

We are making a worm shaft for worm driven trucks, and I believe we can work it out. We will soon have a finished specimen of such a worm shaft completed, and we trust that at some future time we may be able to exhibit this finished piece to you. (Applause.)

President Gary: The fluency and ease with which Mr. Flintermann speaks extemporaneously leads me to the conclusion that he must have had considerable experience on the rostrum.

We have another paper, by Mr. Samuel P. Bush, President of the Buckeye Steel Castings Company of Columbus, Ohio. He is not present; the Secretary has the paper. Will you hear the paper read or have it put in the Year Book without reading?

A Member: Place it in the Year Book.

Motion to print and place in the report seconded and put, and unanimously carried.

President Gary: We are now going to adjourn until two o'clock. The buffet lunch for the members will be served in the Astor Gallery on this floor. The directors' meeting will be held in the State Apartment, this floor, 33rd Street side of the building. We will now adjourn until two o'clock.

At the meeting of the Directors held during the noon recess, Cincinnati was selected as the place for the next October meeting of the Institute, and the following officers were re-elected for the ensuing Institute year: Elbert H. Gary, President; Powell Stackhouse, First Vice-President; Willis L. King, Second-Vice-President; Charles M. Schwab, Third Vice-President; Edward Bailey, Treasurer; James T. McCleary, Secretary.

THE MANUFACTURE OF STEEL CASTINGS

Discussion by Samuel P. Bush

President, Buckeye Steel Castings Company, Columbus, Ohio

Mr. Lamont has very thoroughly presented the history and development of the manufacture of steel castings, and has touched also upon their structural and economic value. To give a further idea of this value it may be pointed out that to-day the truck superstructures of freight cars, passenger cars, locomotives and also locomotive driving frames are constructed almost exclusively of steel castings; in fact, the practice may be regarded as standard. This fact must convey the thought that there can no longer be any doubt as to the reliability of castings when produced according to practice and specifications now prevailing. It may be said, too, that castings for these purposes are produced almost exclusively by the basic process.

It is true, as Mr. Lamont says, that castings produced by the acid process are generally regarded as less subject to certain disadvantageous elements such as porosity, but this is not to say that castings made by the basic process cannot be produced of equal quality in every respect with those made by the acid process. As an illustration of this, some years ago when the manufacture of large steam turbines was in process of development it was thought that the frames or discs could not be constructed otherwise than by building up with rings, inasmuch as complete freedom from such defects as porosity was required; in fact, entire absence of any doubt as to the reliability of the structure was required. The production of these frames or discs was undertaken by one steel castings concern with this requirement in view, and in a comparatively short time these parts were produced by casting to the entire satisfaction of the turbine builders. The surfaces had to be highly finished, to be absolutely free from any surface imperfection, and soundness in every particular was essential.

To-day these parts are produced by no other method than by casting, and quite as often by the basic process as by the acid.

As to the structural value of steel castings, it is only necessary to point out that such a structure as a car or locomotive truck must necessarily be greatly improved by the great reduction in the number of parts required to make a complete structure. Further than this, the casting has a great advantage in effecting a reduction in weight varying from 20 to 50 per cent., which advantage, of course, is reflected in reduction of costs.

For the purposes above set forth, the effect on the reduction of cost must necessarily have been very considerable. Mr. Lamont has spoken of removing internal stresses, and in this connection it may be interesting to point out that in the case of such a piece as a locomotive driving frame it is generally conceded that as compared with a forging, the chances of internal stresses remaining in the structure after finishing are generally regarded as considerably less. Of course, casting lends itself particularly to the production of irregular shapes. The term annealing as applied to castings is often a misnomer. In most cases the annealing process is nothing more than a heat-treating process by which the structure of the steel is changed. Sometimes, however, the process includes not only changing the structure of the steel, but of removing internal stresses and of increasing ductility.

It is yet something of a question whether a casting cannot be produced which with proper heat treatment alone will not closely approximate a forging in physical quality.

Undoubtedly there are possibilities in the art that are yet capable of much development, and it does not seem at this time out of the way to predict that much that is now required in the way of forged material will in the not far distant future be produced by casting.

AFTERNOON SESSION

President Gary: We have a very interesting program for this afternoon, and we should have as many members in as possible. I suggest that those who are sitting in the rear seats come forward. You can hear better, see better, and your being near the front will please the speakers.

Mr. McCleary, I wish that you and two or three others would go out into the hall and let the men there know that we are ready to begin the afternoon session. Meantime, I wish we had a good quartet to sing something for us.

A voice: Start something. (Laughter.)

President Gary: Where's Hatfield? Is Hatfield in the room?

(Cries of "Here he is.")

President Gary: Mr. Hatfield, won't you come up here, and start some patriotic song. That will be an appropriate beginning for the session, and it will attract some of our friends out in the foyer who are naturally busy talking.

(Mr. J. A. Hatfield, vice president of the American Bridge Company, advanced to the platform and led in singing three verses of America, all rising and standing while singing. During the singing the room filled up.)

President Gary: Now, gentlemen, we have a very interesting program and I hope that all can find it convenient to remain here throughout the session notwithstanding your very natural inclination to hold during the meeting conferences with business friends.

The work of this Institute and the sentiment of its members have an important relation to the business of the Government. I am now going to give Mr. E. A. S. Clarke an opportunity to report on a very important matter. Mr. Clarke. (Applause.)

TAKING CARE OF DEPENDENTS OF ABSENTEE EMPLOYEES WHO ENLIST FOR NATIONAL SERVICE

Edmund A. S. Clarke

President, Lackawanna Steel Company, New York

The Chamber of Commerce of the United States has been asked by the Federal Government to prepare a report and recommendations on this subject, so that business firms throughout the country may know what to do, and there may be uniformity of action by all employers of labor.

The Committee was directed by Secretary Baker to make its report to the Council for National Defense. The Committee has met, discussed the matter, after having secured testimony from the most authoritative sources in Great Britain and Canada as to experiences in those countries, and has delayed its report to the Council for National Defense pending final action by Congress as to the methods by which the armies of the United States are to be raised and the settlement of appropriations, etc.

It will be appreciated that it is impossible for special groups of business to take individual action in regard to a problem of this kind without possible misconstruction of motive. It is, however, very proper that attention be given by a body such as the Chamber of Commerce of the United States, which speaks for business interests generally, to a national problem which looms large and serious in the light of the experiences of other countries.

The war came suddenly upon the manufacturers of Great Britain and her Dominions and there was no time for careful deliberation. There was no precedent for dealing with a task of such great magnitude; neither was there any conception that the war would last so long or that the demands to be made upon men and materials would be so terrific.

Since the industrial conditions in Great Britain and Canada—particularly Canada—and the statutes governing same

more nearly than any other country approach the conditions in the United States, it would seem to be sufficient to concern ourselves mainly with the experience of these two countries and seek to profit by their errors, by their new plans and proposed readjustments, and by the advice of their experts who have been most familiar with operations pertaining to pay-rolls and relief.

Spontaneously, in response to the wave of patriotic sentiment which swept the country at the first outbreak, corporations put themselves behind a movement for voluntary enlistment in Canada, and, in addition to every effort to induce the men to enlist and go to the firing line, they one after another agreed to distribute full pay among their employees during the period of the war and to put them back in their positions—those that should return. The result has been something like a chaotic condition in the attempt to handle this great problem. The promises made to continue full pay to the absentee employees who enlisted for service have had to be cancelled, because the corporations could not keep up the pace. And in hundreds of cases where the heads of firms promised to take back those who went to the front they found themselves unable to do even this because men have come home maimed and injured, rendering them entirely unfit for their jobs, to say nothing of disruptions in the organizations caused by the attempt to replace men and women who, though temporarily engaged, have been specifically useful and in turn have to be taken care of in some way when put out of present employment.

The obligation to take care of this help employed at the beginning of the war with the distinct understanding that they were able to hold positions pending the return of the men who enlisted, has not served to solve this angle of the problem, for the reason that hundreds of men and women who formerly earned a few dollars a week have been employed in capacities in which they have been able to earn three and four dollars a day, and the possibilities of discontent and trouble in the disposition of these hundreds of temporary employees have developed far enough to visualize considerable trouble from this point of view alone.

Referring to the family dependents of enlisted men, we find that in Canada the wives have been receiving $20 a month from the Dominion Government and $15 a month from a Patriotic Fund raised by public subscription for this purpose. At first this money was distributed without discretionary power being exercised by the authorities, with the result that hundreds and hundreds of women were discovered to be receiving more money than they have ever been allowed by their husbands, and there developed the ridiculous condition that scrubwomen, suddenly made rich in comparison with previous earnings, began to employ maids in their own households.

All this necessitated considerable readjustment on the part of the distribution of government moneys, and has had to be met by the adoption of discretionary powers by the authorities charged with distributing the moneys from the Patriotic Fund.

As to the remuneration paid to absentee employees who have enlisted, there has been no adoption of a general plan which may be said to prevail throughout the industries as an accepted feasible proposition satisfactory to all.

It appears that the condition in England has been very little better and that the same trouble has had to be met there. The government pays to the wife of every man in the ranks an allowance of nine shillings ($2.25) per week. To this is added an allotment of three shillings and sixpence (a little short of a dollar) out of the husband's pay. Then the Government makes an allowance of a dollar and a quarter for the first child in the family, three and sixpence for the second child and half a dollar for every other child in the family. These are known as Separation Allowances, but they have been found to be totally inadequate with the increased cost of living which has arisen in Great Britain as well as everywhere else in the world. It is understood that the British Government has decided to increase the Separation Allowance and that the men are to be encouraged to make an additional allotment out of their pay. It is believed that this change is to take place immediately.

The British Government has an officer in this country,

with headquarters at the British Consulate, who is looking after the interests of British family dependents here; that is, the members of families of unnaturalized Englishmen who have gone to the front. An investigation has been made calculated to establish the actual minimum cost of living for an average family as a basis for standardizing the allowance.

It is recognized, however, that in regard to all payments beyond this minimum allowance discretionary powers must be maintained by the distributing authorities in order to handle the problem economically and sensibly. By this it is meant that it is impossible to establish any standard figure for the extra allowance beyond the amount estimated as the minimum necessity. Without the exercise of discretionary powers, based upon investigation in respect to each family, it would be found that women who never before received from their husbands more than $5 a week would be receiving as much as women who are in the habit of receiving $10, $15 or $25 a week. While it is a question of common sacrifice and a democratization of the practice of self-denial, it has been found impossible—British authorities say—to handle the problem without allowing for established habits of living and allowance for the circumstances applying individually to dependent families. In other words, it is a case of dealing with each case upon its own merits.

SUMMARY

To summarize the attached report, it would seem that the experiences of other countries, plus the suggestions of their experienced representatives now handling the different phases of the maintenance problem, indicate

1. That enlisted men serving in the ranks of the army or navy neither need nor desire remuneration in addition to the service pay which, in accordance with rank, they receive as a provision of statute, for the following reasons:

(a) They have little or no opportunity of spending money for necessities at the front:

(b) It is not good for them to have it:

(c) It is undemocratic and unmoral to have men serving in the ranks alongside one another with different rates of pay for their patriotism, as must happen if enlisted men receive individual allowance from their respective employers, and such

differentiation has been found to be a contributing factor towards desertions from the ranks.

It has been found that men fraternize together in the trenches under circumstances which lead to exchanges of confidence as the result of a few days' intimate acquaintance not possible under normal conditions. They receive letters from home; knowledge of differences in the standard of family maintenance, emphasized by assistance from several sources, breeds discontent, and discontent leads to desertions.

2. That the government should provide a Separation or Subsistence Allowance (of a minimum sum estimated to take care of sheer necessities, rent and food for the "average" American family of one adult and three children) because

(a) The soldiers do not want their families supported on a charity basis, and government maintenance is the simplest way of covering this difficulty:

(b) The establishment of a *minimum* sum enables discretionary power to be exercised in dealing with each case upon its merits in respect of all additional allowances granted above that made by the government. It is easier to add to than take from an allowance.

3. That all allowances (for clothes, comforts, etc.) above the amount established as the Subsistence Allowance paid by the government should come out of a single fund raised by voluntary public subscription and distributed through a central agency, for reasons already indicated, as well as for the sake of centralizing the burden of public contribution in response to patriotic appeals.

Such Central Agency should be designated by the government as the official body for handling all War Relief efforts, so that there then may be no question as to its authority, nor as to public recognition of its activities.

4. That individual firms and corporations should make *no* definite, irrevocable promises to take men back into their old jobs, but should agree to do this only "insofar as they find it possible."

5. That the government should be urged to announce at the earliest possible moment its intention to "take care" of families of enlisted men (not mentioning any figures), since such assurance has been found to be the surest way of encouraging enlistment.

6. That employers should not undertake individually to take care of their own employees, even though they may agree to do so in conformity with a general plan, because separate, individual efforts of such kind serve to hamper the successful administration of a national problem when once same has been centralized.

Residents of small communities could not be induced to contribute their share to a national patriotic fund if they witnessed the care of the employees of the chief plant, representing, perhaps, the leading or only industry of that locality, by the corporation itself.

Moreover, employers are apt to gauge the pre-enlistment maintenance standard in relation to the dependent family by the

weekly pay-envelope of the wage-earner, whereas that is not the basis of investigation by the authorities who seek to discover the rate of allowances to be made. The first information necessary is "What proportion of the pay-envelope has been going from each wage-earner to this family?" This differs in almost every case, and while it is not necessarily the basis for computing allowances, it is information which must be secured by tactful investigation, and it is information which the employer, as a rule, would be the last to get.

7. Finally, the fundamental aim of the present readjustment of methods on the part of the foreign governments referred to is

(a) To establish *equality* in the basis of service in the ranks, according to rank:

(b) To equalize the burden upon industry and people:

(c) To avoid duplication of patriotic organizations and funds, and to combine all the machinery of family maintenance with an eye to the psychological effect upon the soldier at the front.

NOTES

1. In England and Canada when the soldier enlists he is asked if he is married and for data as to family dependents. Proper forms for registration are submitted to him. He also is asked if he is willing to contribute to the maintenance of his family.

2. The amount of government grant, as well as compassionate allowances from public funds, is conditional upon proof of pre-enlistment maintenance and standard of same.

3. In Canada the Government minimum Separation Allowance is $20 a month regardless of size of family. In Great Britain the government allows so much for the wife, or mother, and so much for the first child, so much for the second and so on.

4. All allowances are based upon known habits of living of each family prior to the enlistment of male members of the household.

The British government makes allowances to the *widowed* mothers of single men and to dependent sisters where pre-enlistment maintenance existed. All such discriminations are the result of experience and detail plans to meet same have been worked out by the British and Canadian governments and are at our disposal.

The lesson taught by the experiences of other countries is that what at first may seem to be the most patriotic thing to do proves, in the light of applied tests, to be the unwise and unpatriotic thing—unpatriotic because working against the best interests of the nation as a whole. Our Allies did not have time to think these things out in advance. Shall not we, who have time for some deliberation, profit by the mistakes of those who have had nearly three years' suffering by which to measure their unhappy, though seemingly unavoidable, errors!

A representative of the Chamber of Commerce of the United States, acting for a committee appointed by them,

called upon me to ask if knowledge of this report which was to be made and of the general scheme could be gotten to the steel industry. It was not with the idea that the steel industry should take any definite action with respect to it at the time, but solely that it should be known that such a plan was on hand, and so that the industry, either in groups or individually or as a whole, should not take any action which would not fall in line with this proposed action should it be taken by the Government. (Applause.)

President Gary: From the time our men began to enlist for service the employers in the iron and steel industry have been considering, and many of them deciding, what they should do with respect to paying the wages of the men while they were in military service, or a part of those wages, and also in regard to taking them back into the employ of the manufacturers after they should return from service. Some of us have acted in one way and some in another. The object of this action on the part of the Chamber of Commerce of the United States is to inform the steel people that this whole question is being considered by the Chamber at the request of the National Advisory Committee or the Council of National Defense or some of the Government officials in order, if possible, to bring about uniformity of action amongst employers generally which should be determined after full consideration of the experience which foreign nations, including Canada, have had concerning the same subject. Therefore, we will do well, I think, to keep our minds open until we have had opportunity to know all that has been done by the Chamber of Commerce, and also what is to be recommended by our government, and in that way no conflict of action will arise to disturb the relations between employers and employes or between different employers. I think Mr. Clarke made it perfectly plain, but I thought I would emphasize it.

We will now have a paper on "The Relative Merits of Forming Steel by Pressing, Hammering or Rolling," by Mr. John Lyman Cox of Philadelphia. Mr. Cox.

THE RELATIVE MERITS OF FORMING STEEL BY PRESSING, HAMMERING OR ROLLING

John Lyman Cox

Engineer, Midvale Steel Company, Nicetown, Philadelphia, Pa.

A finished piece of wrought steel is the result of many operations performed upon it, each of which affects the final result to some extent, though not all to the same extent. Certain of these effects may be masked or wholly neutralized by operations subsequent to those producing them, while others once produced cannot be obliterated but remain to modify the final physical properties of the metal.

The principal conditions upon which the physical properties of steel depend are composition, process of melting, care in melting, design and character of ingot mould, conditions of pouring and of cooling, temperature and time of reheating, amount and character of hot working, finishing temperature, final section, subsequent treatment, and the manner of testing.

As we are to consider particularly the character of the hot working, it might be thought that the other conditions could be ignored, but this is not the case.

A well-melted and well-poured steel is one containing a minimum of undesirable inclusions. These inclusions comprise slags, oxides, bits of brick and other adventitious matter, imperfectly melted alloys, blow holes, which usually contain a droplet of slag, and shrinkage cavities, fissures, or lines of weakness, either primary or secondary; to which, classifying it by some of its effects, might be added the size of ingot crystallization.

Under the influence of mechanical working the inclusions flow in the direction of the flow of the surrounding metal, forming solids or surfaces of cleavage whose influence upon the physical properties of the steel, as shown by bending and tensile test bars, is vast. Defects running lengthways of a test bar act chiefly as slightly decreasing its effective cross-

section, with a proportional lowering of the elastic limit and ultimate strength and with little or no effect on extension or contraction of area. Transverse defects are wholly different; a thin film of slag may almost cut a bar in two, while a small cylinder traversing the surface of a test bar acts as a nick in causing premature rupture with some loss in tensile strength and elastic limit, but much greater proportional loss in extension and contraction.

Now, whenever circumstances permit, a careful engineer lays out his test bars on a piece in the direction in which it will be chiefly stressed in service, that he may have assurance as to its possession of the properties he proposes to use. Thus, for bolts or axles, the tests should be longitudinal; for rotor shafts, with longitudinal slots to hold coils, radial tests might with propriety be asked; forgings for guns or other pieces subject to interior pressure should be tested transversely; shell base plugs should be tested longitudinally.

From the foregoing considerations it follows that to obtain the highest physical results on test steel must be well melted, well poured, and properly worked so as to produce maximum flow in the direction of testing. If flow must be given in other directions, it should be given as early as possible and the final flow be in the direction of testing.

Often it happens that the stresses in an engineering member are not chiefly in one direction, and then it is advantageous to develop the properties in several directions without improving them excessively in one. Thus, a steel plate is usually rolled crosswise and cornerwise before being given its final length; while the belief is general that a forged axle, kneaded back and forth under a hammer or press, is superior to one rolled—with the work all in one direction.

Were steel wholly free from inclusions, or defects which act as such, and were it always given a heat treatment which would break up the slight elongation of the grains in the direction of working, the physical properties would be equal in all directions—and occasionally such a piece is found. Unfortunately the contrary is almost universally the rule, so that a normal or radial bar is a difficult proposition to meet. The more abundant the defects the more

important becomes the question of giving them proper direction—and the more important becomes the choice of the hot-working tool.

An ingot, as cast, possesses a coarse crystalline or granular structure, the size of the granules depending upon the composition, temperature of pouring, character of mould—whether chill or not, method of cooling—whether wire drawn in the mould or not, and the time of cooling. The hotter the metal and the slower the cooling, the coarser will the structure be; while alloy steels tend to have a finer structure than plain carbon steel, and high carbon finer than low. Under similar conditions, the larger the ingot the worse its structure will be, the more apt it is to have internal defects, and the more danger there is in cooling and heating it.

The function of hot working is twofold, to bring the ingot to the dimensions desired in the completed article, and to break up the coarse structure of casting. The finer the final structure the more tough and ductile will be the steel, other things being equal. This final fine-grained structure in turn is dependent on a proper heating, both as regards time and temperature, to break up the ingot structure, and upon a thorough working, during cooling, to complete this grain refinement, a working continued to a temperature throughout which will not allow much grain growth when it is ended. I see little advantage in a great amount of hot working above what is required by these considerations, and much against it. Excessive reduction means larger ingots to start with; larger ingots mean more internal troubles, and more internal troubles mean poorer quality of product.

Let us now get clearly in mind the desiderata in our hot-working machine. It is to reduce to the final dimensions, at least expense, in the least time, an ingot with a section sufficient to give a proper amount of work and a low finishing temperature, and is to pay due regard to the proper direction of the defects inevitably found in the metal.

It is at once to be seen that a number of standards arise according to which we may judge. We have availability for

specific purposes, tonnage output, cost of plant, cost of operation, and quality of product. Of these criteria two or three can be dismissed with a word. Where there is available sufficient tonnage to keep it occupied on work suited to its limitations, a mill is far more economical than either a press or a hammer. It stands quite in a class by itself, so far does it lead its competitors in quantity of output and economy of operation, while it has its own field of thin sections which neither of the others can enter.

It is generally understood that a forging press costs about as much as an equivalent hammer with its foundations. A well-designed press uses probably not one third the steam consumed by the hammer; its tools are lighter and more convenient, being free from shock, and there is much less breakage. In most cases the output from a hammer is less than from a press, but when used for cogging down ingots to small sizes for subsequent rolling, the press cannot compete with the hammer, even though it be equipped with power handling devices.

Under a 10-ton double-acting hammer cogging 14-inch square ingots to 5½-inch square, corners broken, cut in lengths, an average output for 8 hours was 30 ingots, on occasions 34; while the average output of a 1,200-ton steam-hydraulic press was 22 ingots, occasionally 27. This experience was confirmed in another works, where a 500-ton press, bought for a similar purpose, was turned on forgings as it could not do the cogging economically.

There yet remain two standards, availability for specific purposes and quality of output.

The Hammer

The original power hammer was a crude affair compared with the mechanisms we now possess. It consisted of a beam hinged at one end and carrying a die at the other, at an intermediate point engaging cams on a revolving shaft, which alternately raised the free end and allowed it to fall on a bottom die fixed upon a foundation.

Swinging in the arc of a circle, the top die could never be parallel to the bottom except in one position; while the

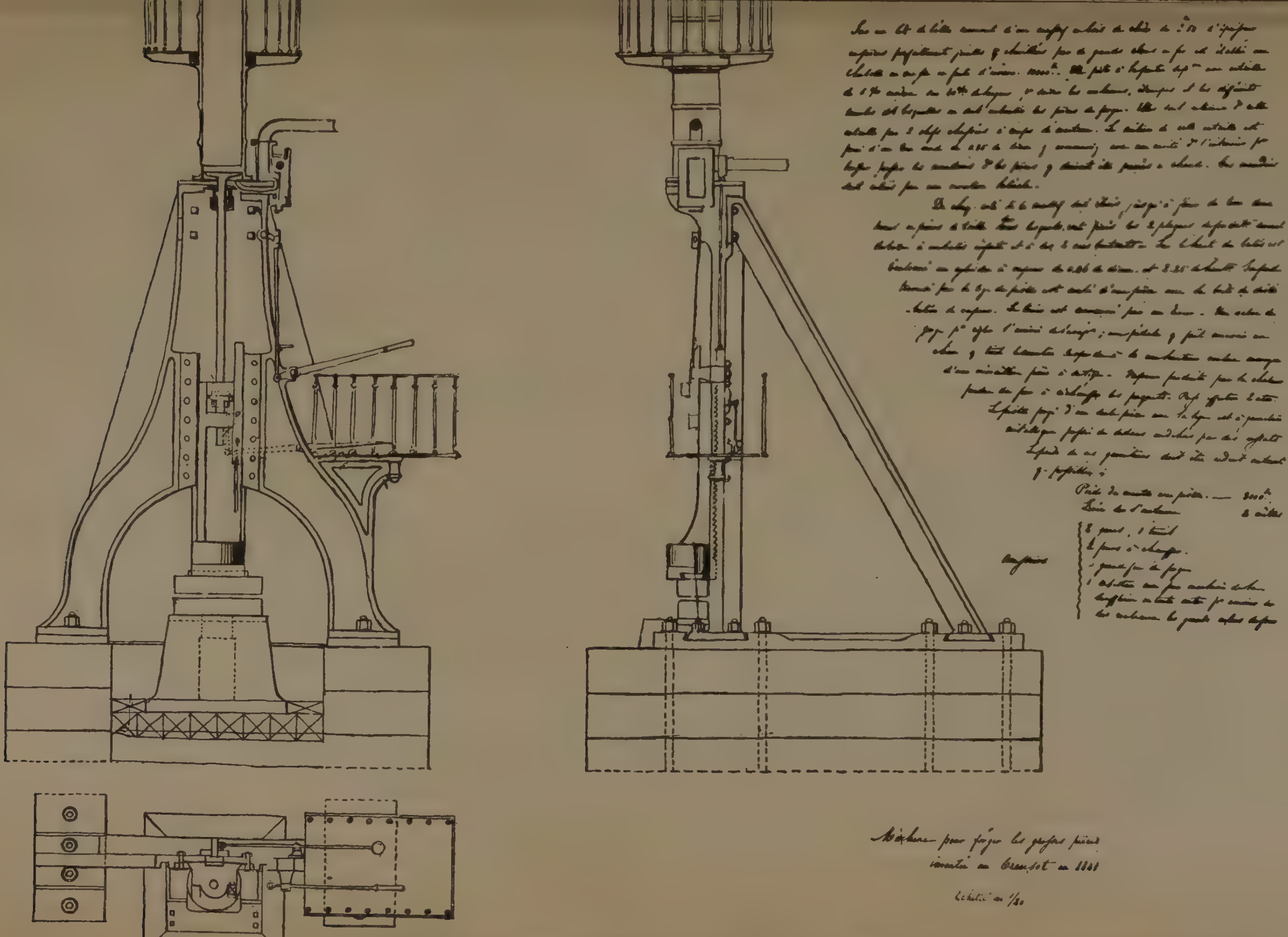
larger the piece sought to be forged, the less the power there was available to forge it, a defect common to all hammers, yet partially overcome to-day by the use of top steam.

This was the situation in 1839 when no one in England could be found to forge the 30-inch iron paddle shafts designed for the steamer "Great Britain." In his autobiography James Nasmyth, of Manchester, England, then engaged in the manufacture of machine tools, describes these conditions and states that on November 24th of that year he sketched in his scheme book his idea of a steam-manœuvered hammer capable of making these forgings.

He writes that he proposed this hammer to several parties as the solution of the shaft problem, but that none was ordered or built because the propulsion of the vessel was changed from paddle to screw, and because there followed a dullness in the iron trade. He said that he was in the habit of showing his scheme books to visitors as that often brought him orders, and that on one occasion when he was absent his partner, Mr. Gaskill, showed to M. Schneider, owner of the great steel works at Creuzot in France, and to his able engineer, M. Bourdon, this scheme book and especially this drawing, and that M. Bourdon took careful notes and sketches of its constructive details.

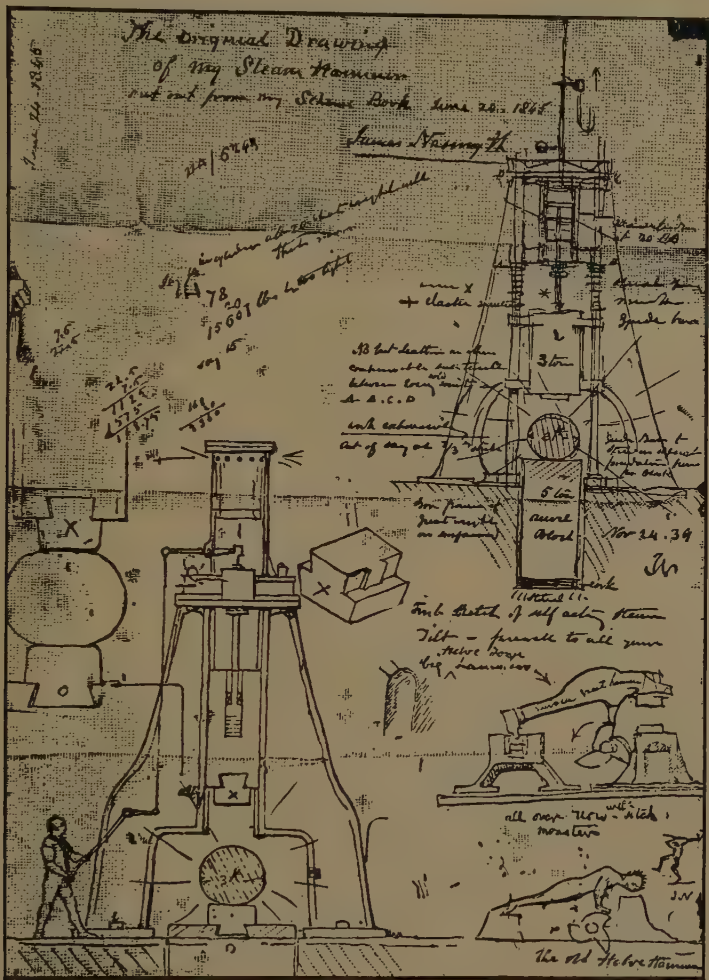
In April, 1842, Mr. Nasmyth visited le Creuzot, finding M. Schneider absent but M. Bourdon at home. To quote his words: "M. Bourdon received me with much cordiality. As he spoke English with fluency I was fortunate in finding him present, in order to show me over the works; on entering which, one of the things that particularly struck me was the excellence of a large wrought-iron marine engine single crank, forged with a remarkable degree of exactness in its general form. . . . I inquired of M. Bourdon 'how that crank had been forged.' His immediate reply was, 'It was forged by your steam hammer!'"

"Great was my surprise and pleasure at hearing this statement. I asked him how he had come to be acquainted with the steam hammer. He then narrated the circumstance of his visit to the Bridgewater Foundery during my absence. He told me of my partner having exhibited to him the original



Drawing of Bourdon Steam Hammer made by James S. Cox in 1842.

design, and how much he was struck by its simplicity and probable efficiency; that he had taken careful notes and sketches on the spot; that among the first things he did after



Nasmyth's Original Sketch of the Steam Hammer.

his return to Creuzot was to put in hand the necessary work for the erection of the steam hammer; and that the results had in all respects realized the high expectations he had formed of it."

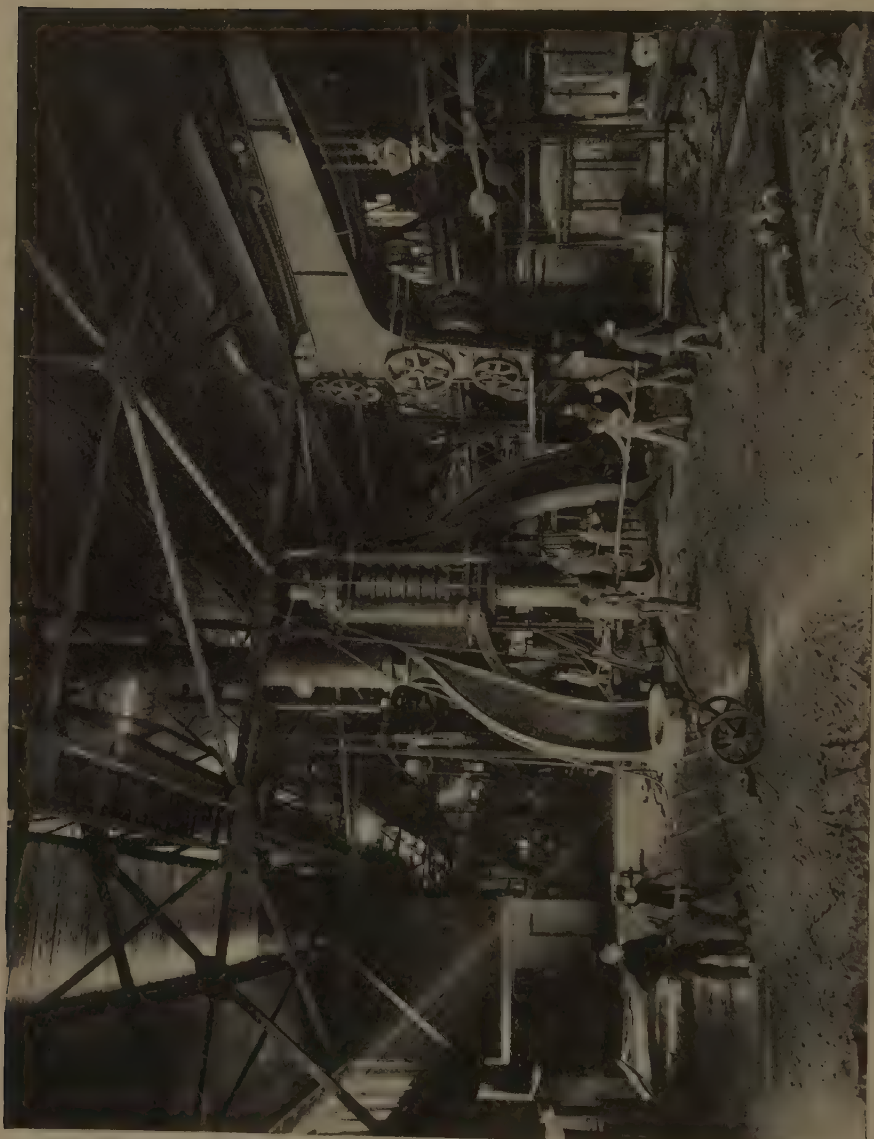
"M. Bourdon conducted me to the forge department of

Old Forge Shop of the Midvale Steel Company.

the works, that I might, as he said, 'see my own child;' and there it was, in truth—a thumping child of my brain! . . . On inspecting the steam-hammer I found that Bourdon had omitted some important details, which had led to a few mishaps, especially with respect to the frequent breaking of the piston-rod at its junction with the hammer-block. . . . I sketched for him, then and there, in full size, on a board, the elastic packing under the end of the piston-rod, which acted, as I told him, like the cartilage between the bones of the vertebræ, preventing the destructive effects of violent jars. I also communicated to him a few other important details, which he had missed in his hasty inspection of my design. . . . He expressed his obligation to me in the warmest terms, and the alterations which he shortly afterward effected in the steam-hammer, in accordance with my plans, enabled it to accomplish everything that he could desire."

There appears to be little doubt that the first to conceive the idea of a steam-operated hammer was Nasmyth, but in justice to M. Bourdon I think the following facts should be known. The story is one never yet published.

In the month of April, 1842, my father, the late Mr. James S. Cox, of Philadelphia, then just twenty years old, was visiting M. Bourdon, at Creuzot, in the south of France. My father had graduated as an engineer at the École Centrale des Arts et Manufactures at Paris the previous August and had spent the intervening time in visiting various industrial establishments throughout Europe. Among others he had visited the Schneider works and become acquainted with M. Bourdon, who took a great fancy to him. M. Bourdon, although he spoke little English, had been in the United States, liked Americans, and invited my father to visit him. One day, during this visit, M. Bourdon asked my father if he had ever seen a steam hammer. On being told that he had never heard of such a tool, M. Bourdon took him into the penetralia of the works, where, surrounded by many precautions, a steam-hammer was running. Much impressed by what he saw, my father asked and received permission to copy the drawings of this tool. The tracing



10-Ton Double-Acting Steam Hammer.

which he then made is now in my possession and from it was made this photograph. The place and date of the invention are given on it as Creuzot, 1841.

One day a hurried message was received by Mr. Cox from M. Bourdon asking him to come down at once to the works and interpret for him as he had an English visitor. Mr. Cox promptly responded and accompanied the gentlemen into the works and to the steam hammer, where, standing at the side of James Nasmyth, he explained the working of the tool to him.

That night at dinner Mr. Schneider, who had been absent during the day, asked M. Bourdon whether there had been any guests that day at the works. On being told, "Yes, Mr. Nasmyth of England," Mr. Schneider started up saying, "You did not show him the steam hammer, did you?" M. Bourdon replied, "Yes," whereupon Schneider struck the table a blow with his fist, exclaiming, "By Heaven, he'll patent it in England to-night."

Mr. Nasmyth returned to England and, according to his autobiography, immediately took out patents on the steam hammer, the agency for which in the United States he thereupon offered to my father whom he had never met but once, of whom he knew nothing, who was only just out of college, was but twenty years old, had no business experience, nor business connection in the United States, and who had not been in America since he was seven. This flattering offer my father declined through loyalty to his friends, believing that Mr. Nasmyth was not entitled to the profits of the invention. Subsequently the American agency was given to Mr. Samuel Vaughan Merrick, of Philadelphia, who accepted it with perfect propriety and to whom it proved most profitable.

In order to permit a careful comparison to be made between the two machines of Mr. Nasmyth and M. Bourdon, I have had them reproduced (pages 124 and 125), and I call attention to the comparative crudity of the French design, which it seems rather remarkable that an engineer of M. Bourdon's capability should have produced after "taking careful notes and making full sketches" of Mr. Nasmyth's design.

Owing to its power being derived from the inertia of the falling mass the steam hammer has least power when it most

25-Ton Double-Acting Hammer.

needs it, on large diameters, and vice versa. The need of power on large diameters is twofold—the forging must be worked to its center to break up ingot structure, as well as

to prevent grain growth, and large diameters involve large die contact areas with corresponding pressures.

In 1882, when the Midvale Steel Company took its first order for 6″ Navy Rifles, its forge shop was equipped with Morrison type hammers, the largest being a 10-ton double acting hammer with 35″ steam cylinder and 6′ 6″ stroke.

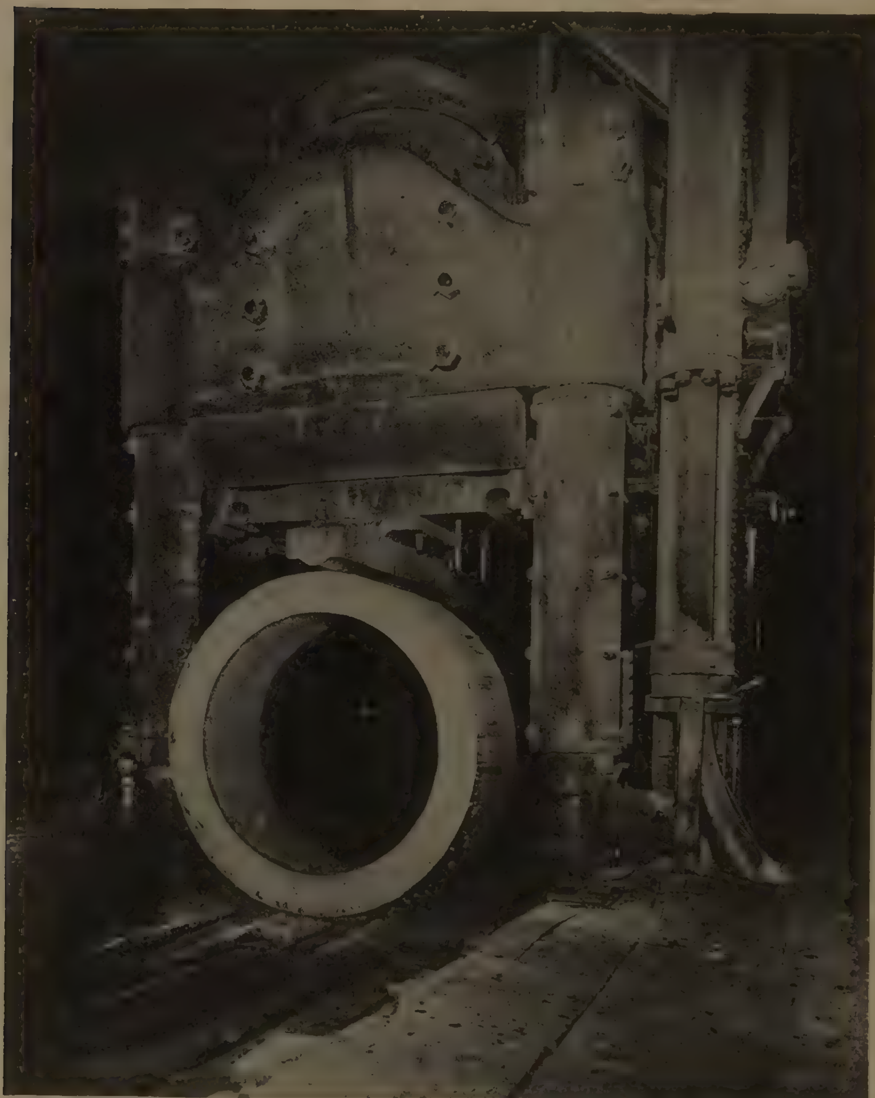
The tubes were made from 25″ octagon ingots reduced to 13″ rounds tapered to 11″ at the muzzle, and the jackets from 30″ squares reduced to about 17½″ rounds. For these operations the hammer had sufficient power, although the cogging of a 30″ square to a 20″ octagon was a slow proceeding. In 1885 the Company took an order for a short 8″ Rifle for the Army, the jacket of which had to come from a 38″ octagon. That increase of 8″ overstepped the boundary. Although in time the gun was finished, the 38″ ingot was clearly beyond the proper range of the 10-ton hammer.

With the increase in the size of naval guns a heavier tool became necessary, and in 1888 the Midvale Steel Company began the erection of a 25-ton double-acting hammer with 50″ cylinder and 9′ 6″ stroke, built by the Morgan Engineering Company from designs by the late Frederick W. Taylor. This tool was probably the most effective hammer ever built. The forging was controlled entirely by power. The ingot was brought from its heating furnace to the hammer with the free end of its porter bar fastened to a trolley in an underground conduit. When the ingot was landed on the die, the trolley was disconnected and on the porter bar was thrown a heavy ring connected by a wire rope to a horizontal underground hydraulic cylinder which did all the weighing-on of the usual crowd of men. The 60-ton traveling forge crane rotated the piece on the die and the overhang was sustained at first by a gantry, later by a 25-ton traveling crane.

With this powerful tool 13″ gun forgings were made in quantities from ingots as large as 63″ octagon, in spite of predictions to the contrary, and with excellent results.

The largest hammer ever built was the 125-ton single-acting hammer of the Bethlehem Steel Company, intended for the forging of armor plate. Both it and the 25-ton double-acting hammer of Midvale, really a 75-ton as com-

pared with a single-acting hammer, have been abandoned for forging presses.



Large Rotor Drum Under 10,000 Ton Press, the Midvale Steel Company.

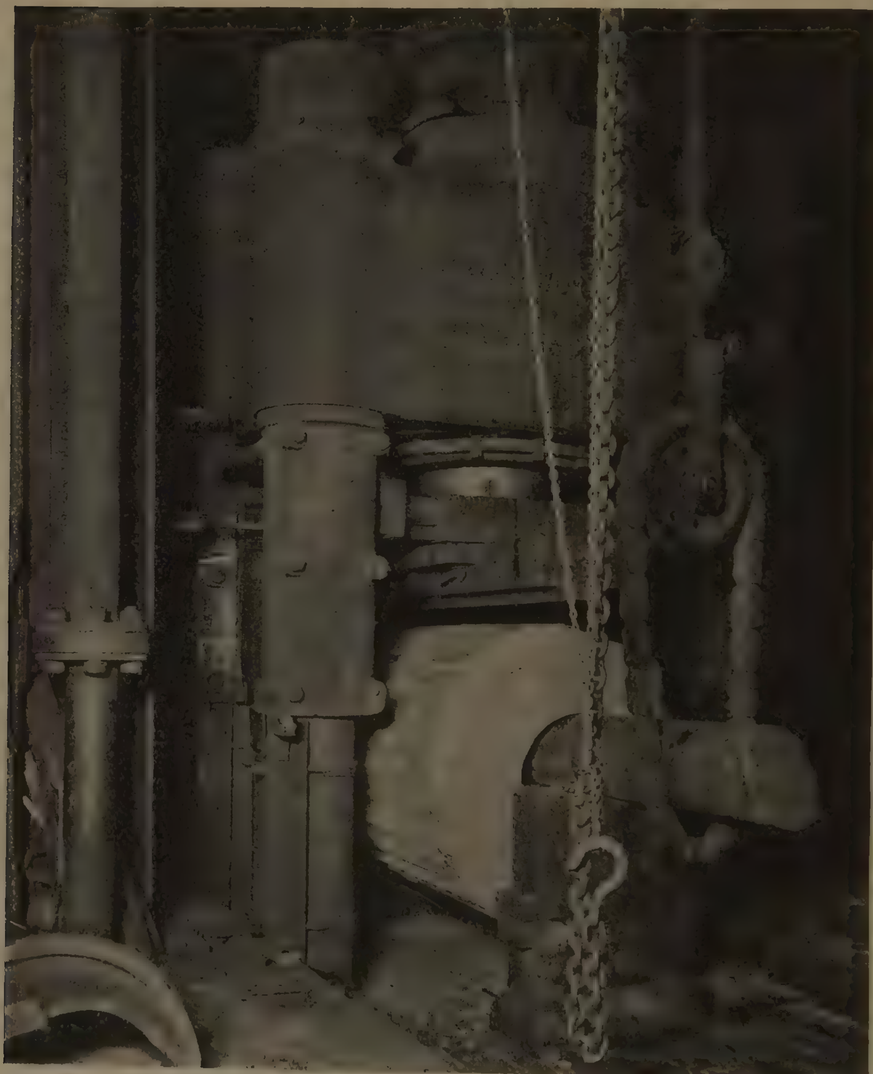
With the exception of the tube, which is generally made solid, the larger forgings for heavy artillery are usually made

hollow, as are marine shafts and other forgings when desired of especially high quality. As it is difficult to manipulate under a hammer, in upsetting and punching, blocks too heavy to be handled on levers, it is customary to bore the ingot with a hole of suitable size and cut from it a hollow block of proper weight for the job in hand. The hole in this block must be larger than the mandrel upon which the block is to be forged, involving great waste of metal if the mandrel be large. To avoid this waste, and in the case of gun forgings to assist in the proper direction of the contained imperfections, the billet if first bored with a smaller hole, then hung upon a mandrel supported at each end in a housing die keyed on the anvil block in place of the bottom die, and by blows upon the periphery as the billet is turned upon the mandrel its walls are thinned and the interior diameter increased until it is of the desired size. It may then be placed upon a drawing mandrel of the proper diameter for the final bore and drawn out in a V die to the desired exterior form and size, if required.

The width of a hammer anvil block is not great and if the forging be heavy it is in practice necessary to use an ingot of initial section sufficient to give the requisite weight in the short length that will go between the cheeks of the mandrel housing, for upsetting of heavy blocks under a hammer is impracticable, as previously stated. The employment of ingots of large cross section being objectionable for reasons already given, as also because of the added dangers in cooling and reheating and in the time consumed thereby, we have here one weakness of the hammer. It cannot make the great hollow forgings easily producible under a press, such as shown on the opposite page.

It might be urged that an anvil of a special design would permit the use of long billets of less diameter, but a long unsupported mandrel will not withstand the impact of hammer blows. So little time is given for the flow of the hot metal that the force of the impact is transmitted in large part directly to the mandrel, which breaks. A 14″ mandrel on a span of 45″ to open a hole some two inches is about the limit

for a hammer; a larger mandrel must be substituted as soon as possible.



3,000-Ton Whitworth Forging Press, the Midvale Steel Company.

When made under a hammer of ample power forgings show test results practically identical with pressed forgings made under the same conditions, so long as neither be ex-

panded. This is shown by the following table, in considering which it must be borne in mind that all the forgings were fully heat treated by quenching and drawing, which would tend to obliterate any slight differences which might exist in the forgings originally.

When circumstances permit an equal amount of expansion there would be a similarly close agreement between the tests of properly hammered or pressed forgings, but beyond the point where hammer expansion is possible the advantages are altogether with the press. Lest it be thought too much stress is laid upon the advantages of expansion in the manufacture of hollow forgings I will cite an experience of the Midvale Steel Company with jackets for a lot of 12″ steel coast defense mortars. These were rather short forgings drawn on about a 19″ mandrel and bored originally with a 20″ hole. The hole was so small that it had been decided expansion would not pay. As on testing the jackets gave a great deal of trouble it was concluded to bore the ingot with a 14½″ hole, expand it on a 14″ mandrel to 16¼″ in diameter, substitute a 15¾″ mandrel and expand on it to 20″, after which the forgings were drawn in the V die as before. This expansion of the hole increased the outside diameter by only 1⅝″, giving that much more reduction in the V dies to be sure, but the amount of testing was reduced 21 per cent., as an average of 38 forgings of each kind.

The danger in solid hammered work is always that for economy's sake too light a hammer will be used and the forging left with an imperfectly reduced grain size towards the center.

The Forging Press

In 1861, Manassah Gledhill, of Manchester, England, invented the forging press. Mr. Gledhill was at first an employee and later an associate of Sir Joseph Whitworth by whose name the press became known. It was another case of "The page slew the boar, but the peer had the glorie." For many years this wonderful machine was used secretly in the Whitworth shops, and so far as I am aware it was not

until 1887 that it was sold for outside use and was brought to this country by the Bethlehem Iron Company.

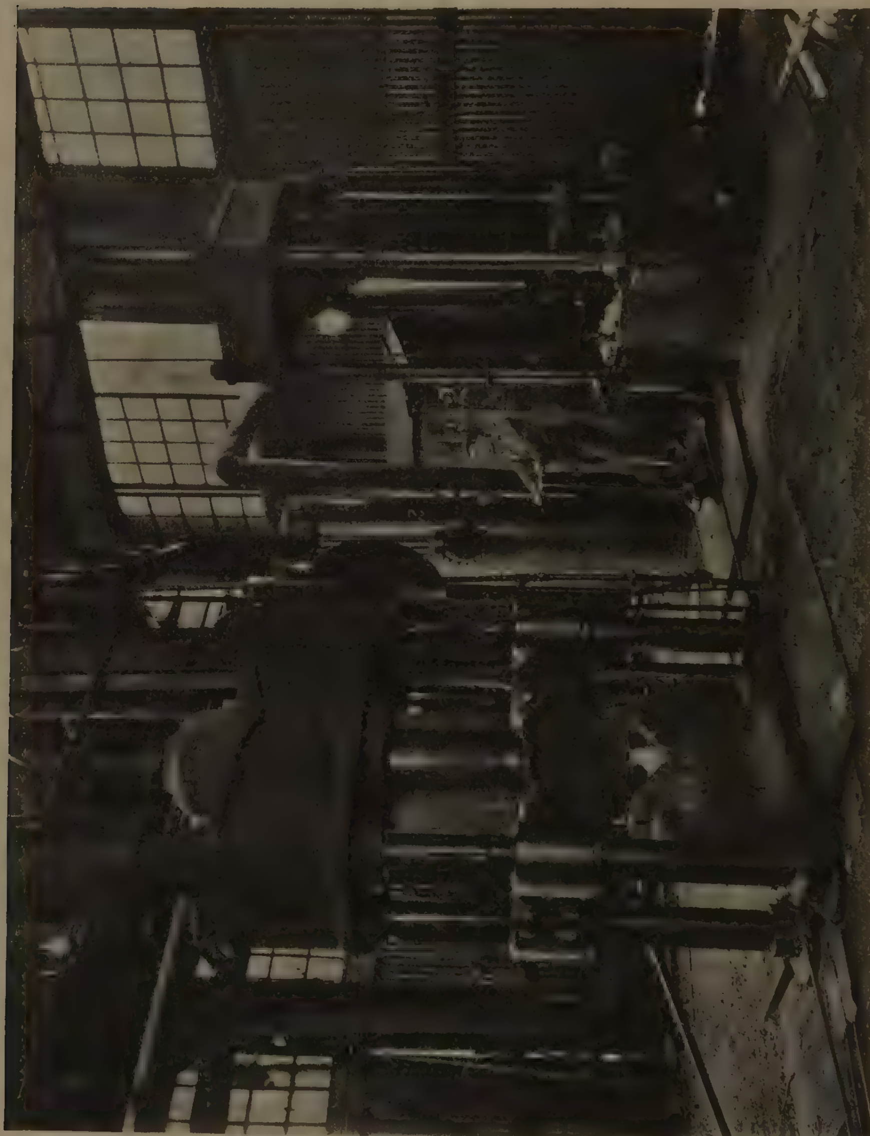
14,000-Ton Press, the Bethlehem Steel Company.

The press consists of two massive heads held together by forged steel bolts and separated by distance pieces. In the

upper head is fastened an inverted hydraulic cylinder, the lower end of whose plunger forms the upper crosshead, which is guided by shoes running on guides forming part of the column distance pieces, and to whose lower face are attached the various top dies. The upper surface of the lower head is flush with the bottom of a shallow pit extending on each side of the press, floored with heavy cast iron plates. In two grooves on each side of the press travel heavy wrought steel flats attached at their press ends to two low cast iron forging carriages, and at their outer ends to the crossheads of long reversed hydraulic cylinders which form part of the floor of the forging pits and whose plungers extend outward away from the press under the shop floor. These cylinders serve to move the carriages toward the press and away from it, the blocks being held in line by the grooves in which the flats run.

The upper surfaces of the two forging carriages are arranged with mortises to take the tenons of various auxiliary tools, the most notable of which are the housings for the expanding mandrels. Being mounted on these carriages, the housings can be set as near together as may be desired or as far apart as the width of the bottom press head will allow, thus permitting the use of the shortest possible unsupported length of mandrel. Since a press is wholly self contained and its movement comparatively slow, giving time for the flow of the metal, there is no rebound of the anvil block to throw out of position a forging being expanded, and successive impressions of the top die can be made very close together. This permits the use of narrow-face dies, reducing to a minimum the load to be borne by the expanding mandrel. As small a mandrel as 11″ can be used with a 5′ span with no more liability of breakage than a 14″ mandrel with a 45″ span under a hammer.

Because the bottom of the forging pit is on the same level with the bottom head, it is easy to place upon it a hot billet and by means of a forging carriage push it under the press, where it can be readily upset and punched and pushed out by the other forging carriage when it is finished, an operation impracticable for heavy pieces under a hammer. Owing to



500-Ton Steam Hydraulic Press.

its facilities, the press is especially suited to the manufacture of long, hollow forgings, such as marine engine shafts.

The pressure produced by a hammer is directly proportional to the effective stroke, inversely proportional to the contact area of the dies and to the distance through which the pressure is exerted, and would be infinity if the distance were zero. The pressure exerted by a press is independent of the stroke, is definite in amount, equalling the net power of the tool divided by the contact area of the dies and the piece being forged. In making round forgings this area is small if the stroke be short and the dies be not deeply buried in the plastic metal, thus permitting a comparatively small press to make large shafts. With a large press, excessive die impression will be prevented by fear of lapping; with a smaller press, by the die contact area increasing until the press is overpowered and forging ceases. In press forging the work is turned up after every stroke, thus always presenting a new and smaller contact surface.

In cogging down an ingot under a hammer, before rounding-up begins, several blows are usually struck in the same spot until fear of lapping stops them. Due to the inertia of the part of the ingot beyond the die, at the instant the blow falls there is a tendency to cock up the end of the piece, and as there is no ready means of taking out this short kink, except by turning the piece upside down, the tendency is to let it occur and for the hammer die to cut in more deeply on one side of the ingot than the other, gradually throwing the axis of the forging out of the axis of the ingot. This does not occur under a press. There the tendency is for the live die to cut in a little deeper than the dead die and bend the piece down; but the piece is revolved after every impression, which tends to keep it straight, and as the movement of the press is comparatively slow, the cranes lower in unison with it. If the forging becomes bent, if not too stiff it can be straightened by one of them pulling up while the pressure is on, or by running up the forging carriages and straightening the piece between them.

I have spoken of the speed of the press. In large tools of the Whitworth type this varies from about 12½′ to 16½′

per minute. In finishing, 30 to 40 short strokes can be made per minute, the practical limit being in the speed of the turning mechanism. Some steam hydraulic presses run still faster and are capable of giving 60 to 80 strokes per minute in sizes where the work can be turned by hand.

On plain die work it usually takes a larger press than is generally understood if the finishing temperatures are to be kept low, which is necessary for the best class of work.

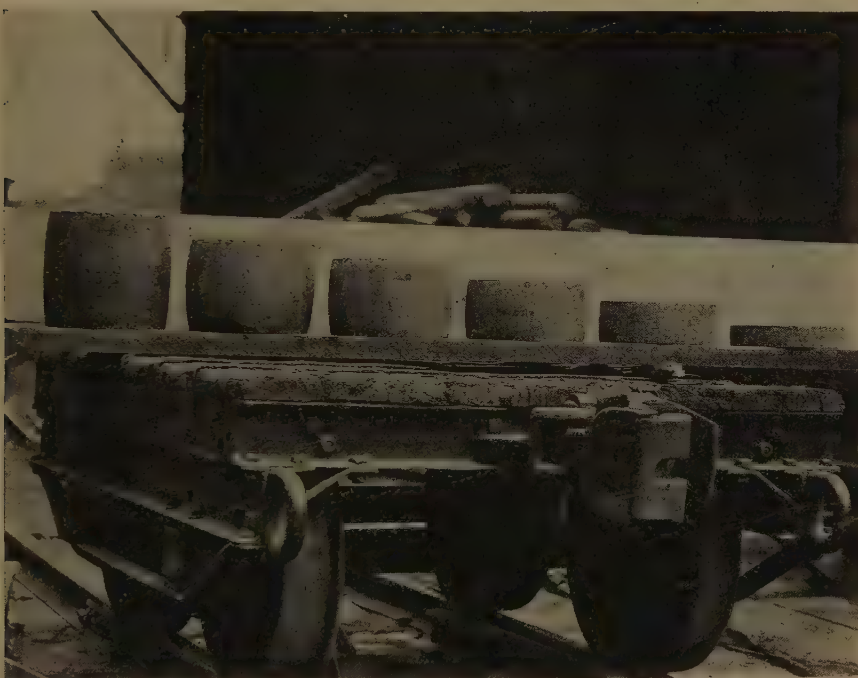
The lowest forging pressure per square inch of die contact area of which I know as being effective was 1.2 tons per square inch, with which it was possible to edge-in an ingot 90″ wide at a full forging heat, and from this the pressure runs up to 13¼ tons per square inch, which it takes to completely fill the sharp corners of moulds for steel wheels.

Dr. Coleman Sellers, in a lecture reprinted in part in the *Railroad Gazette* of December 25, 1891, stated that 3,000 to 4,000 pounds per square inch is quite sufficient to deform hot steel when the mass is free to expand sideways, but from 16,000 to 20,000 pounds is required to fill sharp corners in a mould, and for some complicated shapes very much more. In practice I believe these pressures to be too low, especially for plain die work under practical conditions, and, moreover, they take no account of the thickness of the piece being forged. The pressure per inch required for forging depends upon the composition of the steel, its temperature and its thickness, is a direct function of the hardness of the piece, and an inverse function of the other two quantities. Thinking that it would be of interest and possibly of value to make some experiments along these lines, I had prepared a series of 18 blocks of steel of the following composition:

Carbon	.40
Manganese	.455
Phosphorus	.064
Sulphur	.062
Silicon	.131

These blocks were rough turned 11⅛″ in diameter and cut to lengths of 2″, 4″, 6″, 8″, 10″ and 12″, one of each length in a set, there being three sets in all. All the blocks

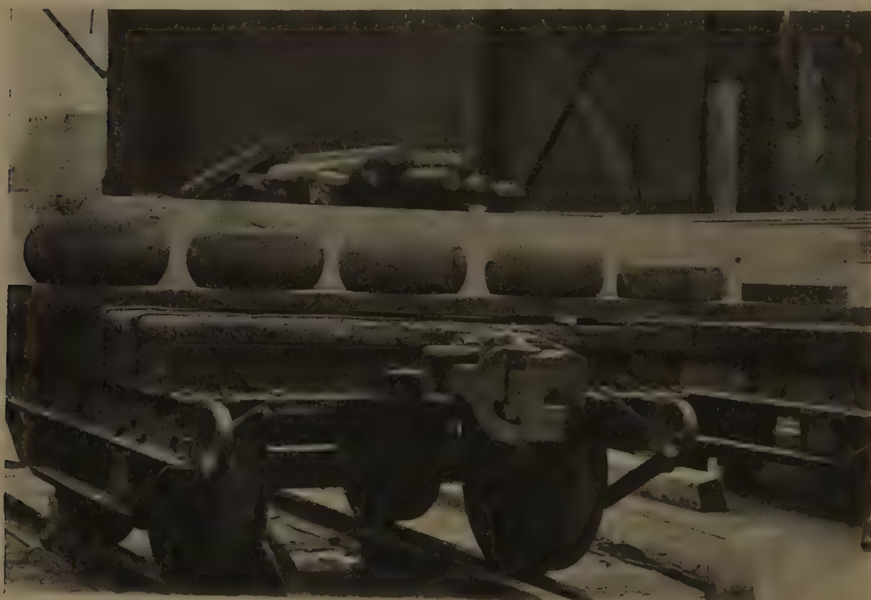
of each set were heated in a furnace to as nearly as possible the same temperature, the first set to 1,550° F., the second set to 1,700°, the third to 1,850°, the temperatures being read by a Leeds & Northrup optical pyrometer of the Holborn-Kurlbaum type. The lowest temperature selected was chosen as a common, though rather high, finishing temperature for forgings, the highest an example of bad practice and the intermediate a mean. Of course, at a full forging heat of



Experimental Forgings Upset at 1550°F.

from 2,200° F. to 2,300°, far more would have been accomplished than at the temperatures of the experiment. What was deemed ample time was allowed for the pieces to reach and soak out at the specified temperatures, which are probably correct within about 50 degrees. In nearly every case this time seems to have been sufficient. As rapidly as possible the pieces were carried by hand from the furnace to the 16½″ diameter plain dies of a 500-ton steam-hydraulic

forging press* and there subjected at once to the full pressure of the tool. This pressure was kept up as long as there was any flow of the metal visible on the dial of the press. The upsetting was rapid at first and became slower and slower as the contact and median diameters of the forgings increased, as the thickness decreased, and as the temperature fell. The shortest time given was 25 seconds, the longest 1 minute, 45 seconds. The shortest squeezing period was several times



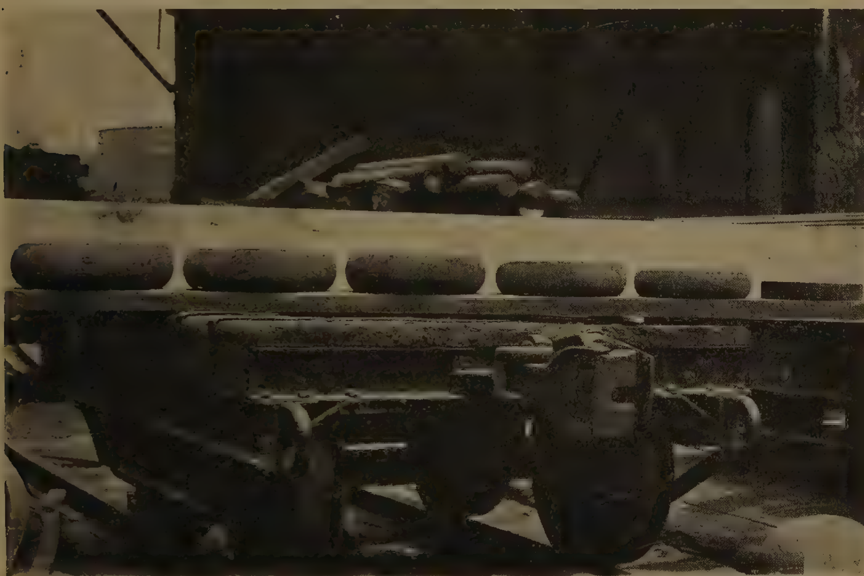
Experimental Forgings Upset at 1,700° F.

that which would be allowed in practice. The blocks were measured as to length and diameter both before and after upsetting.

A hydraulic pressure gauge of the Bristol type had its clock work removed and a drum substituted therefor on the chart spindle. This drum was connected by a string to a drum on the shaft of the press forging dial and was counter-weighted. Arcs traveled on the chart by the recording pen

* Press has 16⅜″ diameter cylinder, giving 500 tons with a water-pressure of 4,750 pounds per square inch of ram area.

were thus proportional to the vertical movements of the press head. The pressure element of the recorder was connected to the line running from the steam-hydraulic intensifier to the press cylinder. For ease of comparison the curves obtained have been replotted in rectangular co-ordinates by Mr. G. B. Staples of the Midvale staff. The photographs show the appearance of each set of specimens after upsetting.



Experimental Forgings Upset at 1,850° F.

The first set of charts shows the effect of the thickness of the piece upon the result obtained at a fixed temperature; the second set shows the effects obtained by variations of temperature on pieces of the same thickness.

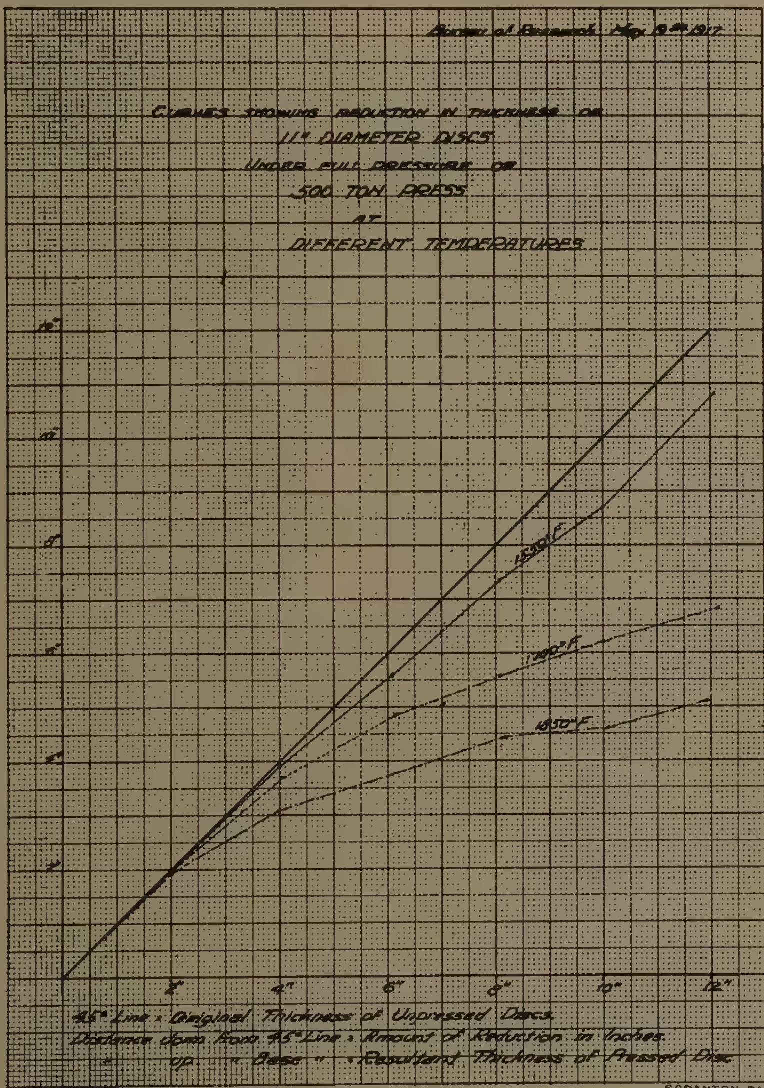
It will be noticed that the ram pressures per square inch vary somewhat. This was due to fluctuations of pressure in the steam line, as the test extended over many hours. The lowest recorded pressure per square inch of ram was 4,850 pounds, the highest 6,250 pounds. The curves show that with from 5.6 tons to 6.2 tons per square inch of contact area or median line there was practically no flow of metal in a

2″ piece at temperatures between 1,550° and 1,850° Fahr., and that the amount of flow increased rapidly with increase of thickness and increase of temperature. Calculated on the final contact areas of the dies and corrected for variations in hydraulic pressure, the lowest contact pressure obtained was 3.57 tons per square inch and the lowest final median pressure 2.00 tons, measured on a 12″ piece. These results show that on plain dies and for thin flats, to successfully forge steel at the temperature chosen pressures much higher than 6 tons will be required.

Friction between press die faces and their work is very great, while the longer time of contact as compared with the hammer tends to chill the surface of the forging and to prevent flow along the die faces. This results practically in a reduction of the effective thickness of the forging and an increase in the pressure required to forge it. For the metal to escape from the pressure, it must flow from the center outwards between immobile surfaces and this it was practically impossible for it to do in the thin blocks of our experiment. It was held in place by internal friction.

	Length		Mean Diameter		Final Pressure per Square Inch—Corrected Tons of 2000 lbs.	
	Initial	Final	Contact	Median	Contact	Median
1550°	2	$1\frac{63}{64}$	$11\frac{1}{8}$	$11\frac{3}{16}$	5.69	5.62
	4	$3\frac{29}{32}$	$11\frac{1}{8}$	$11\frac{23}{64}$	5.63	5.40
	$6\frac{1}{16}$	$5\frac{39}{64}$	$11\frac{1}{8}$	$11\frac{43}{64}$	6.23	5.66
	$8\frac{1}{16}$	$7\frac{11}{32}$	$11\frac{1}{8}$	$11\frac{3}{4}$	5.74	5.15
	10	$8\frac{11}{16}$	$11\frac{1}{8}$	$12\frac{3}{16}$	5.96	4.96
	$12\frac{1}{16}$	$10\frac{7}{8}$	$11\frac{1}{8}$	$11\frac{27}{32}$	5.96	5.65
1700°	2	$1\frac{31}{32}$	$11\frac{1}{8}$	$11\frac{11}{64}$	6.17	6.12
	$4\frac{1}{32}$	$3\frac{43}{64}$	$11\frac{1}{8}$	$11\frac{45}{64}$	6.22	5.57
	$6\frac{1}{8}$	$4\frac{27}{32}$	$11\frac{1}{4}$	$12\frac{13}{16}$	5.82	3.88
	$8\frac{1}{16}$	$5\frac{37}{64}$	$11\frac{43}{64}$	$13\frac{55}{64}$	5.31	3.77
	10	$6\frac{13}{64}$	$12\frac{1}{16}$	$14\frac{53}{64}$	5.06	3.35
	$12\frac{1}{8}$	$6\frac{63}{64}$	$12\frac{3}{8}$	$15\frac{15}{32}$	4.81	3.08
1850°	2	$1\frac{15}{16}$	$11\frac{1}{8}$	$11\frac{9}{32}$	6.23	6.06
	4	$3\frac{3}{32}$	$11\frac{39}{64}$	$12\frac{31}{32}$	6.22	4.98
	$6\frac{1}{16}$	$3\frac{3}{4}$	$12\frac{43}{64}$	$14\frac{5}{8}$	4.76	3.57
	$8\frac{1}{16}$	$4\frac{27}{64}$	$13\frac{1}{8}$	$15\frac{37}{64}$	4.28	3.04
	$10\frac{1}{16}$	$4\frac{19}{32}$	$14\frac{9}{32}$	17	3.19	2.25
	$11\frac{15}{16}$	$5\frac{7}{64}$	$14\frac{5}{8}$	$17\frac{3}{16}$	3.57	2.41

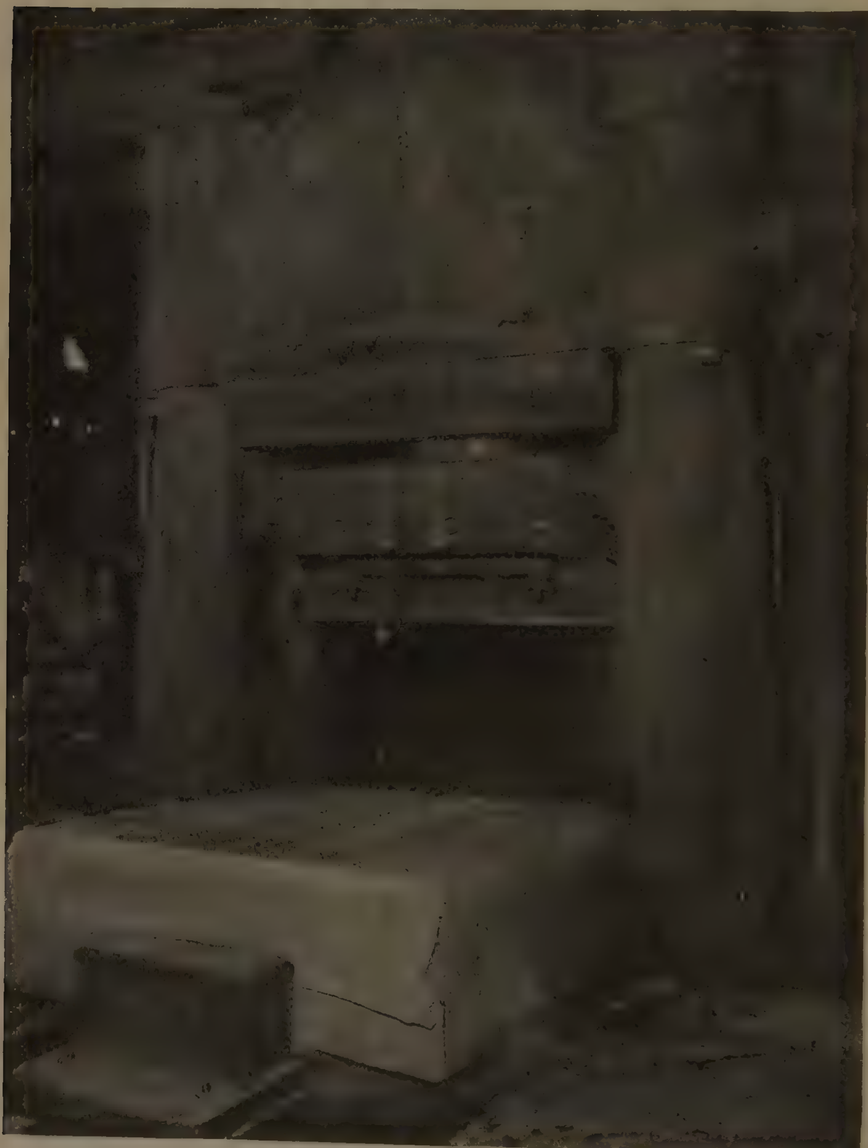
I have here a plate showing graphically on one sheet the relative effects of the various thicknesses and temperatures employed in this experiment.



Curves of Final Results.

The important influence of thickness is corroborated by two full-sized experiences where, in upsetting at full forging

heat a 37″ octagon slice from 43″ to 13½″ in length, it required 8,700 tons which, figured on the areas of the final diameters of 59″ and 65″ at the die face and center respectively, gives 3.18 tons per contact inch and 2.6 tons at the



Hot-Planed Armor Plate Billet.

center; and in upsetting a 48″ round 45″ long to 33″, where it took only 1.4 tons per square inch of contact area and 1.3 tons per square inch of median area, on account of the extra thickness of the piece.

The advantages of absence of shock, in addition to the weight to be handled, in forging such masses of steel as shown here can be readily appreciated by everyone, yet in spite of all its excellencies and its adaptability to a wider variety of work, even such as hot planing the defects from heavy armor plate, the press has two short-comings, both due to its lack of impact: first, it is harder to get rid of scale; second, it cannot strike in a mould as large a forging as a hammer its equivalent in other respects. In our experience we consider a 500-ton press the equivalent of a 2¼-ton hammer, a 1,200-ton press the equivalent of a 10-ton hammer, a 2,500-ton press the equivalent of a 25-ton hammer; yet a 4½-ton hammer can make drop forgings which are beyond the power of a 1,200-ton press, and a 2¼-ton hammer can about equal it.

As illustrating the great difference between the steady pressure of a press and the impact of a hammer, I will show three separate indicator cards from the foregoing experiment.

The full stroke of the steam-hydraulic intensifier at this press gives only 4″ ram stroke, neglecting leakage; to go beyond this it is necessary to exhaust the steam cylinder, during which operation the ram rises, then lower down the ram, which is done by forefilling with water, and take another stroke. In his haste to resume pressing the driver dropped upon the billets the ram with its crosshead, guides and dies, a weight of about 5,100 lbs., urged by 60 pounds of air pressure in the forefilling tank, producing a hammer blow. The forging effect of the blow is apparent. As flow under subsequent pressure occurred in two of these cases, the hammer effect was included in the curves already shown, but in the third case the last blow was effective beyond the effect of the press proper and it was not included. In the comparative curves the inflection due to these extra strokes was not shown as it tended needlessly to complicate the diagrams.

It remains to be said that in both pressing and ham-

mering the final results depend much upon the skill and good judgment of the forge man.

The Rolling Mill

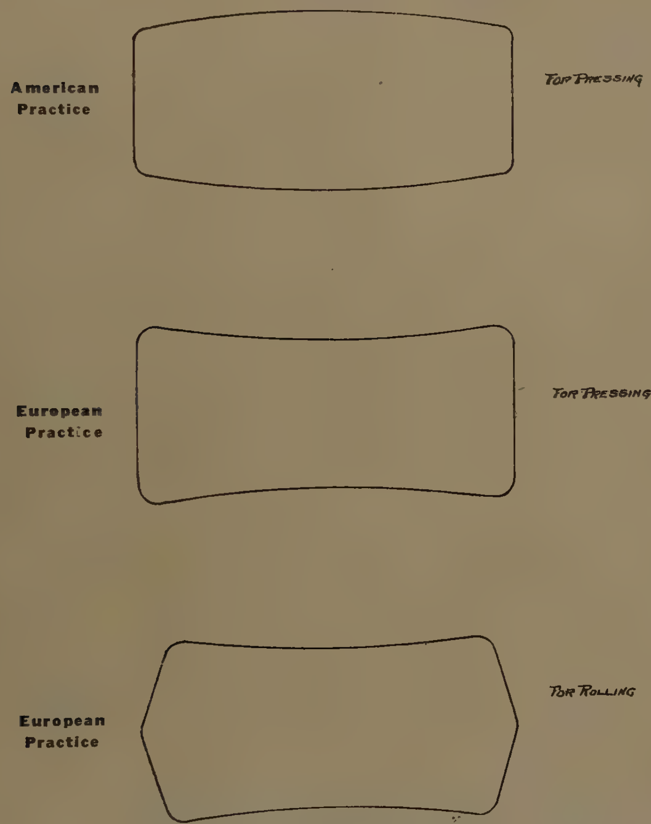
To institute a comparison between the effects of rolling and the effects of hammering or pressing is much more difficult than to compare with each other the effects of the two latter

Hot-Planings from Armor Plate Billet.

methods. Each has wide fields of application with fairly well defined boundaries, yet there is a neutral zone in which both operate. Heavy plates are produced both by the press and mill, billets and medium sized rounds, squares and flats, by all three instrumentalities, and small regular sections of tool steel by the hammer and the mill.

The action of a rolling mill is quite different from that of

either the hammer or press. In both of these latter the action of the pressure is normal to the face of the die and the pressure equal at all points on flat die faces. In the rolling mill compression is most rapid, and therefore the pressure greatest, at the line of intersection between the faces of the rolls and the surface of the unreduced portion of the object



Armor Plate Ingot Cross Sections.

going through them. There is also a much narrower limit in reduction and none can be taken in excess of that which can be pulled between the rolls by the friction of their surfaces with the hot metal, frequently assisted by the ragging of the rolls.

The tendency of rolling is to have a more superficial action

Galloway Tire Mill.

than either hammering or pressing; thus to avoid excessive loss through fishtailing the sides of armor plates there is often made a distinct difference between the cross section of the ingot for rolling into armor plate and the section used for pressing into the same plate. Under a press the sides of the straight-sided ingot bulge slightly outward at points about halfway between the center line and each face but remain nearly straight; between the rolls the center of the diamond sided ingot stretches very slightly in width but the upper and lower surfaces run out along the rolls, producing approximately straight sides in the finished plate. A straight-sided ingot would make a concave-sided plate, if not one actually lapped.

The operation of rolling is far more rapid than either pressing or hammering, with a consequent high finishing temperature. Again, a roll being generally in the condition of a beam supported at each end and loaded at some intermediate point, is much less able to stand high pressures than either a press or hammer and the fear of breaking rolls is always present in the roller's mind, as well as injury done to the shape of the passes by cool rolling.

The three points just considered constitute, I believe, the reasons for the common inferiority of rolled products. If a heavy mill were to roll its products from ingots at a low initial rolling temperature and finish them at the same temperature as material laid down from a press or hammer, I believe that the difference between rolled and forged products would largely disappear.

A slight evidence of this is shown in the case of a lot of 10⅜″ rounds, some rolled from 30″ squares made at one plant, and some forged from 20″ squares made at another plant. Thirty-six longitudinal test bars taken on the axial line from 13 rounds from each lot and thoroughly annealed, averaged, from the rounds rolled with great reduction:

		C	Mn
Tensile Strength........	88,057 lbs.		
Elastic Limit...........	53,273 lbs.	.43	.70
Extension in 2¾″.......	21.7 per cent.		
Contraction of area.....	46.5 per cent.		

On the rounds forged with a smaller reduction:

		C	Mn
Tensile Strength	87,400 lbs.		
Elastic Limit	51,750 lbs.	.41	.64
Extension in 2¾"	19.5 per cent.		
Contraction of area	40.9 per cent.		

Hot-rolling tends to prevent the development of surface defects, but hot-rolled material will not give good results

Forging 12-inch Jacket under a 3,000-Ton Press.

on physical test, hence it is common for rolling mills to refuse orders for billets to show definite physical properties and to insist upon a chemical test only, whereas forged billets are frequently tested physically.

Due to the difference between the methods by which they are produced, there is often a distinct difference in the cross section of rolled and forged plates.

In a single cylinder press, the crosshead, being supported only in the center under the ram, is free to bend upwards toward the ends, resulting in the plate being thinner in the center and thicker toward the edges; while the rolling mill, with its rolls supported at the ends and free to bend in the center, tends to produce plates thicker at the center than at the edges. This tendency in plate mills is overcome by slightly increasing the diameter of the rolls toward the middle.

Owing both to the rapid cooling of thin plates and to the excessive pressures required for their production under the press, it is found that there is a practical limit to the thinness of the forged plates at about 5″.

In this country all except the thinnest armor plates are pressed, but in Europe, where the demands for armor are sufficiently great to warrant investment in a machine capable of the great output of a mill, armor plates are frequently rolled. Enormous mills for this work exist in a number of public and private establishments, both in England and on the Continent. At one English works, certainly until recently, the custom was to rough out the plates under a press, cut off the scrap and finish them by rolling.

One process that the mill cannot carry out is the reforging of an armor plate after carburization. This must be done at a low heat under a press, with a minimum disturbance of the carburized face.

There remains another form of the rolling mill which we have not considered—the tire mill. The early schemes for our coast defense called for a large number of 12″ mortars consisting of a cast iron body reinforced by steel hoops. As the hoops were of some 3 ft. inside diameter and there was no forge in the country equipped for making them of con-

siderable length, they were divided up into sections not over 13″ long, which could be easily rolled in a tire mill.

These hoops were manufactured by cutting from a 20″ round ingot blocks of the proper weight, upsetting and punching them under a steam hammer, beaking them on the horn of an anvil, and then rolling them to diameter in the tire mill, which can produce rings approximately 20″ in width. Every step of the operation was in the direction of the expansion of the diameter. Owing to the forgings being without end they could be chilled rapidly as they neared final dimensions and they almost always filled the specifications on the first submission, rarely requiring retreatment. On one order, out of 305 test bars broken from the hoops only two, showing small defects, failed to give the requirements and then extra bars met them. (Applause.)

President Gary: Discussion of this paper by Mr. E. O'Connor Acker, Bethlehem Steel Corporation.

THE RELATIVE MERITS OF FORMING STEEL BY PRESSING, HAMMERING OR ROLLING

DISCUSSION BY E. O'CONNOR ACKER

Bethlehem Steel Corporation, South Bethlehem, Pa.

There can be no doubt that the men in the Forging Business as well as users of steel forgings are under great obligations to Mr. Cox for his valuable paper on this subject, embodying as it does, his years of experience in this work. It is to be regretted that he has not had time to write a complete treatise on the subject.

We note from Mr. Cox's paper how simple a matter it is to manufacture a good forging, depending as it does upon the

1. Composition.
2. Process of Melting.
3. Care in Melting.
4. Design and character of ingot mold.
5. Conditions of pouring and cooling.
6. Temperature and time of reheating.
7. Amount and character of hot working.
8. Finishing temperature.
9. Final section.
10. Subsequent treatment.
11. Manner of testing.

This is somewhat in line with the historic remarks of the distinguished Ordnance Engineer, Mr. John F. Meigs, to the effect that "the making of good steel is a matter of fasting and prayer." While all the points in Mr. Cox's paper are of the greatest importance, I will only have time to dwell on one or two of them; one of the most important is the proper finishing temperature and probably this has been neglected as much as any other point in the making of forgings in this country. Perhaps not over 10 per cent. of the forgings made to-day are finished at the right temperature. Many years ago when Mr. Owen Liebert brought over to Bethlehem the practice of the Whitworth Company, it was customary to finish much colder and to very much closer dimensions than is done to-day. Part of this is undoubtedly due to the

fact that at that time steel shafting was selling from 8 cents to 10 cents per pound but since then prices as low as 2 cents and 2.25 cents have been received.

The forgings made at that time usually had a glaze or polish as coming from the forge and were very true to dimensions; the physical results obtained from this material were such that the younger generation of people in the business do not credit them as being true and this in spite of the fact that heat treatment at that time was not as well understood as it is at present.

We made a shaft for the U. S. Cruiser "California" which averaged in six different test bars 70,000 pounds tensile strength per square inch with an average elongation of 40 per cent. and this shaft was simply annealed at a temperature of about 1,150 to 1,200 degrees Fahrenheit. In other words, the proper forging at the right finishing temperature puts into steel a condition which cannot be equalled by giving the most approved heat treatment to forgings which are not properly made. This is a subject which is not well understood and the microscope does not seem to aid in its solution.

Some of the members of the Institute may be familiar with the rifle barrel steel which is used by the U. S. Government in the manufacture of small arms; the qualities of this steel are so high that it is necessary to finish it at the rolls at a temperature slightly below the absorption point of the steel and the qualities usually obtained in this material are about 130,000 pounds tensile strength per square inch, 75,000 pounds elastic limit per square inch with 20 per cent. elongation and about 50 per cent. reduction of area. These bars after being rolled have the same glaze or polish as the shaft before mentioned.

The General Electric Company has a specification for bars approximately 5-inch in diameter which they require to be swaged under a hammer; these bars give extremely high physical qualities which they probably believe is due to the swage action. Undoubtedly, however, these qualities are simply obtained on account of the fact that the finishing temperature in this operation is about what it should be for this class of steel. It will be noted from Mr. Cox's paper

that there is no inherent virtue in a press as distinguished from a hammer, as far as the physical condition of the forging is concerned, but an important point is that the tool doing the work should be in proportion to the size of the work done; in other words, we would expect a shaft made under a hammer of the proper dimensions to be very much superior to a forging made under a press which was too light for the work, modifying this statement by the fact that it is practically necessary to make large hollow forgings under the press.

The principal reason we do not get as good a condition in rolled material as compared with forged material is also due to the higher finishing temperature at which material leaves the rolls, the reason for this being, of course, that loss of output and breakage of the rolls would necessarily result from attempting to finish at nearer the proper heat.

The rolled armor plate to which Mr. Cox referred in the latter part of his article, is rolled by very powerful mills in which the finishing temperature is kept fairly close to what it should be, but even in that case the work does not penetrate to the middle of the masses as well as it would if the plates were forged. It would seem than an axle finished at the proper temperature in the rolls should be at least equal to that made under a hammer if the finishing temperature is the same, because undoubtedly the regularity with which the work is applied from the rolls must be to its advantage.

The idea now largely held that scientific heat treatment can correct the effect of improper forgings is very much in line with the idea that improper melting can be cured by adding "medicine" to the ladle.

In conclusion, attention might be drawn to the importance of the fact, as mentioned in the first part of this paper, that the proper melting in the furnace is only a part of the right condition of steel in the ingot as the designs of the molds and the proper method of pouring are equally important.

President Gary: Surgical Discoveries of the War and Their Application to Industrial Accidents by Dr. Sherman of Pittsburgh. (Applause.)

SURGICAL DISCOVERIES OF THE WAR AND THEIR APPLICATION TO INDUSTRIAL ACCIDENTS, HUMANITARIAN AND ECONOMIC FEATURES.

William O'Neill Sherman, M.D.

Chief Surgeon, Carnegie Steel Company, Pittsburgh, Pa.

There are, approximately, 75,000 deaths annually from accidents in the United States, with 2,000,000 or more major and minor accidents. In 11 months of the year 1916, there were 25,000 accidental deaths with 225,000 accidents in Pennsylvania. Many of the deaths were the result of wound infection; approximately 10 to 15 per cent. of the wounds received were infected. Ordinarily it takes from four to five times as long for an infected wound to heal as one that is not infected. The prevention of wound infection is a tremendous economic factor as well as a humanitarian one. The chief causes of death from accident are shock, hemorrhage, and infection. Where the injured is not killed outright, but lives for 24 hours and then dies, the cause of death in 75 to 80 per cent. of this class of accidents is due to infection. Eighty per cent. of the amputations in the present war are the result of infection; 95 per cent. of secondary hemorrhage is due in infection. Eliminating actual destruction or loss of tissue in accidents, the vast majority of the complications are due to the infection that takes place in the wound. Heretofore, the medical profession has never had a cure for infection after it had once made itself apparent, other than the mere opening of the wound with free drainage. The first-aid treatment and immediate attention, together with the use of antiseptics, have greatly reduced the number of infected wounds in industrial accidents, but at the same time, many of the extensive wounds became infected in spite of every effort to prevent its occurrence.

The most commonly used antiseptics, viz., carbolic acid and bichloride of mercury, are used to destroy the bacteria,

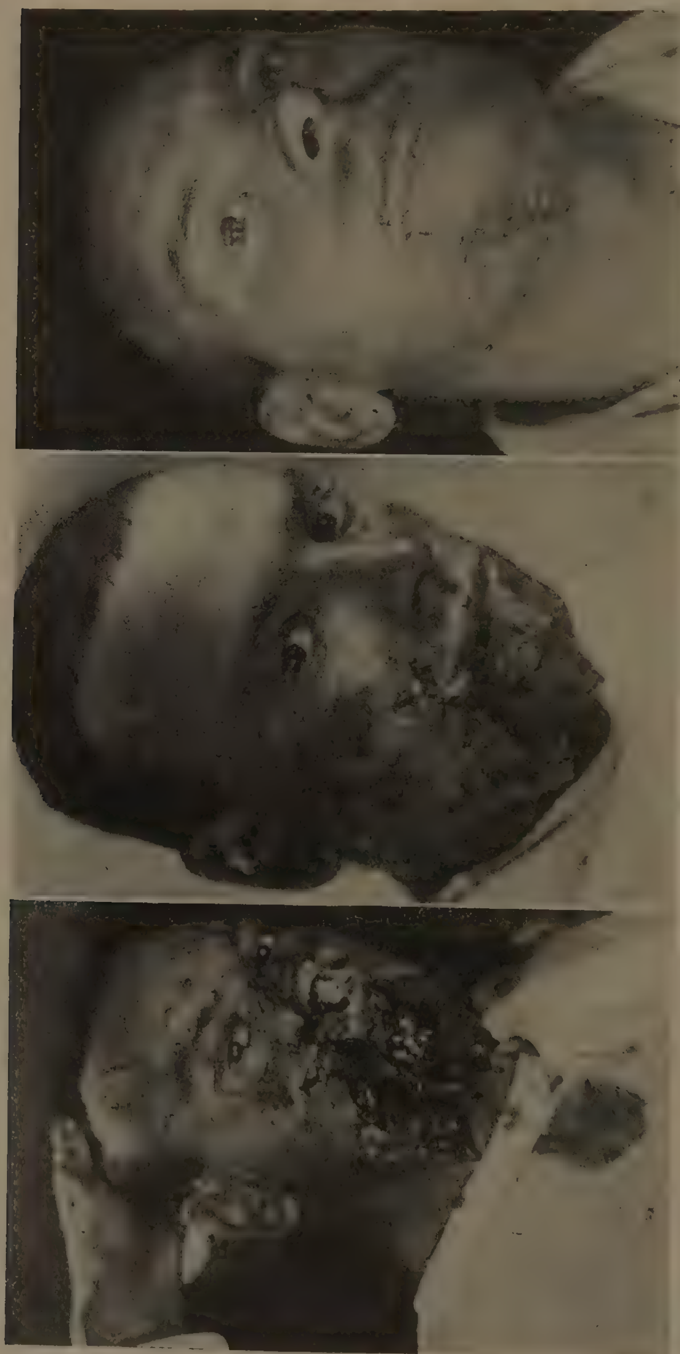
and if used in sufficient strength, would also destroy the tissue and be poisonous to the patient if used continuously.

The problem of controlling wound infection had never been satisfactorily solved until Doctors Alexis Carrel and H. D. Dakin, working in France under the auspices and direction of the Rockefeller Foundation, discovered a method that not only aborts wound infection but cures it after it is once established. Dr. Carrel recognized at the very beginning of the war that the control of infection was the great

Compound comminuted fracture of leg, labeled "Amputate on arrival." Finochietto's stirrup extension to os calcis with Carrel's tubes in position. Free suppuration on admission. Dressings had not been changed for five days previous to admission to hospital. Infection under control in five days. The functional result secured was far superior to an artificial leg. (Courtesy Professors Gosse and Chutro.)

problem that confronted the surgeon, and unless some method was discovered to control infection, thousands of deaths, amputations, and cripples would result.

After experimenting for a number of months, during which time several hundred different antiseptics were used, Carrel and Dakin perfected a method which is now being used throughout the allied armies with wonderful success. There is every indication that this treatment will be made



Shell wound of face and lower jaw on admission. Middle picture three weeks later. Picture at right shows recovery in six weeks. Facial deformity not very marked. (Courtesy Professor DePage.)

obligatory in the United States Army, Navy, and Public Health Service. This would, unquestionably, save many lives and amputations and eliminate many of the unfortunate complications that result from infection.

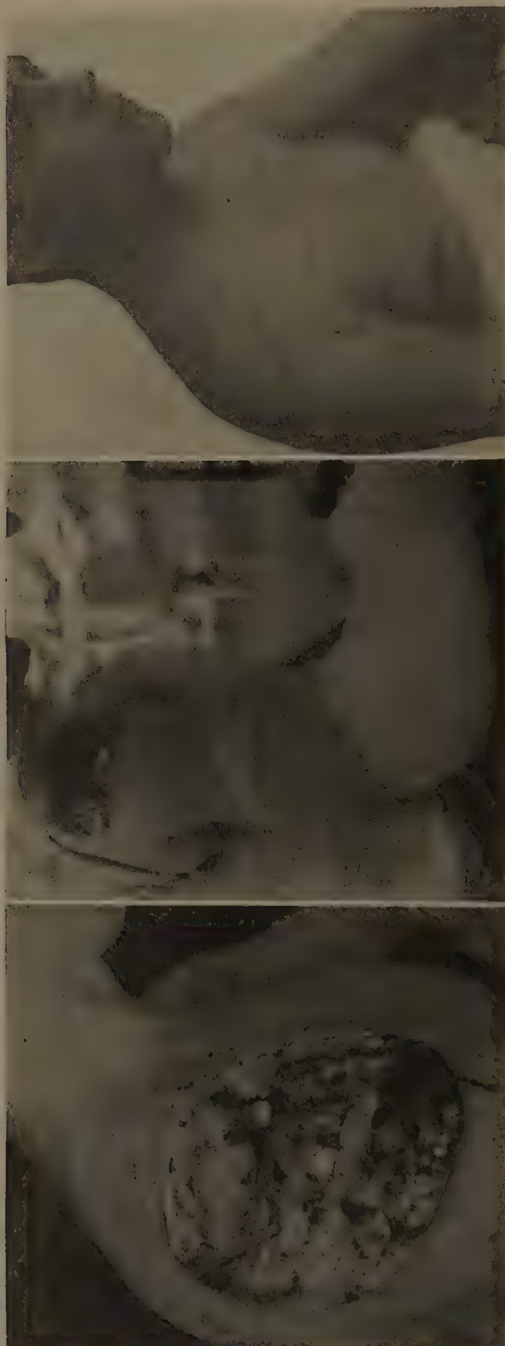
Dakin succeeded in making a solution with intense antiseptic properties, which is non-irritating and does not destroy the tissues; when it can be used in large quantities without danger to the patient. The simplicity of manufacture and its low cost make it almost an ideal antiseptic. The antiseptic consists of a solution of 25 per cent. chlorine activity bleaching lime in 1 to 200 dilution. To this solution sodium bicarbonate and carbonate are added, to free it from caustic alkali.

While this solution is almost an ideal antiseptic, it is of very little use unless the method of its application, as devised and perfected by Carrel, is carried out in detail. This method consists of the introduction of the antiseptic into the wound through a number of small rubber tubes with small perforations staggered along their walls so as to allow the solution to be equally sprayed into all parts of the wound. This injection is carried out every two hours.

By means of this treatment, infection is prevented if it is begun within the first 24 hours. If the treatment is started after infection has become established, it can be cleared up in from seven to ten days. The majority of these patients get well in one-third the time it would require under former methods. The method is practically free from pain and discomfort.

Dr. Chutro, professor of surgery at the University of Buenos Ayres, who has been surgeon to the Hospital Buffoon, Paris, for the past two years, states that where formerly he performed 20 amputations, only one now is necessary, and where there were from 12 to 15 deaths from infection, he now has one. These wonderful results were secured by using the Carrel method.

While the character of infection of wounds received in the European war is more virulent than that in wounds received in this country, the same general deductions can be made. The high mortality and virulence of the infection in



Extensive shell wound of shoulder. The head, neck, and upper end of the humerus were completely destroyed—"Blown away." Repair and suture in eight weeks. (Courtesy Professor DePage, Hospital Ocean, La Panne, Belgium.)

France and Belgium are due to the contamination of wounds from the intensely cultivated soil of these countries, the soil containing the most poisonous micro-organisms known to science. The infection is carried into the wound either from shells or bullets which carry with them particles of clothing which are impregnated with this poisonous soil.

It will readily be seen that Carrel's and Dakin's discovery is going to be of tremendous value to industrial America. It will not only save a great number of lives and amputations, but will enable the injured to return to their former occupations two or three times more quickly than heretofore. The method is being rapidly adopted in this country and it will be but a short time until the surgeons in every industrial corporation in the United States will be using it. Since the writer's return from Europe in November, 1916, a number of amputations have been prevented, as well as a number of lives saved, by the prompt use of this method.

Another surgical discovery which will be of great use to the industrial surgeon is the discovery of a new method of treating burns. This method consists in the spraying or painting of a liquid paraffin, beeswax, and rosin mixture, directly over the burn. The preparation has a very low melting-point, the treatment is comparatively free from pain, and the patients recover two or three times more quickly than under any other method, and are practically free from scar. This method has also been made compulsory in the English and French armies and navies. Heretofore all burn treatments were more or less unsatisfactory in that they were very painful and scar formation could not be prevented.

Had it been possible to introduce these treatments and make their use compulsory in the allied armies two years ago, at least 150,000 lives and 75,000 amputations could have been saved. It is to be regretted that all medical discoveries meet with opposition, and as a result, years elapse before they are generally accepted by the profession. To the credit of American surgeons let it be said that they, as a rule, are free from prejudice and are ever anxious to employ the method which is best for the patient. Carrel's contribution

Second degree burn both hands. Completely healed in three weeks, no scar formation.

to humanity is one of the greatest advances in medicine since Lister's discovery of antisepsis.

The writer wishes to again thank Dr. Carrel and the Rockefeller Institute for the many courtesies extended and the opportunity to study and witness at first hand this wonderful method of wound treatment. (Applause.)

President Gary: The program calls for informal discussion of each paper under the five-minute rule. Are there any who desire to discuss this paper? (Mr. John A. Penton of Cleveland arose.) Mr. Penton.

SURGICAL DISCOVERIES OF THE WAR AND THEIR APPLICATION TO INDUSTRIAL ACCIDENTS, HUMANITARIAN AND ECONOMIC FEATURES

DISCUSSION BY JOHN A. PENTON

President, The Penton Publishing Company, Cleveland, Ohio

MR. PRESIDENT: It seems to me that I would not be doing myself justice, and I would not be doing justice to the American Iron and Steel Institute, to the United States Steel Corporation or to the Carnegie Steel Co., which so generously sent Dr. Sherman to France to make the investigations of which he has told us, neither would I be doing Dr. Sherman himself justice, were I to allow this occasion to go by without giving some expression to a thought or two that came to my mind while listening to his very wonderful paper, which I regret I did not have an opportunity of seeing before he read it.

Last year I had the opportunity of being in France at the same time Dr. Sherman was there. I saw a great deal of him for a month or two, and I know something of the work in which he was interested while in that country, concerning which he has shown us something this afternoon; and I think there are a few phases of this matter that might be appropriately referred to here.

In the first place, the Doctor has spoken of the very large number of deaths which possibly could have been avoided, and the hundreds and thousands of amputations which would not have been necessary, had there been a universal adoption of the Carrel method which he has so graphically described. He very lightly touched upon the fact that there has been in this case, as is usual in matters of this kind, very much professional reluctance to adopt new plans, theories or methods. I was so situated that I happen to know a good deal not only of that reluctance but also of the opposition in France to the adoption of Dr. Carrel's methods.

It is true, of course, that America is now winning a golden harvest from the French people for the unselfish work and devotion of the hundreds, if not thousands, of nurses and ambulance drivers in France, all of them Americans, who have in the most unselfish and patriotic way imaginable gone over there, many of them at their own expense, to give their time and incur every risk to life and limb for the sole purpose of relieving the suffering, saving life, ministering to the wounded and doing everything in their power to aid the people living in that grief-stricken country. These have been a very important factor in bringing to America a wealth of good opinion, which I think we little appreciate, and very prominent among the number thus highly honored is the gentleman who has just sat down.

I happen to know that, with his own inborn American business instinct, his appreciation of the value of organization and his knowledge of American organization methods, Dr. Sherman very rapidly grasped the possibilities of this new process; and I know also that, owing to his very earnest effort and his unselfish devotion to the cause, supported by the influence of other people from this country, Dr. Sherman was able to bring pressure upon some of the members of the House of Deputies in Paris to such an extent that they were contemplating making the adoption of this method almost obligatory upon the part of all of the surgeons in all of the hospitals in France, and there were over 2,000 of them in France last year caring for the sick and wounded.

It is my understanding from what I have heard that later on Dr. Sherman went to Great Britain and had interviews with some eminent surgeons in that country who were skeptical of the value of the process; but he was more or less successful in inducing them to have Dr. Carrel's method more generally adopted, although of this I have heard nothing from Dr. Sherman myself, this information coming to me indirectly.

As a result, therefore, of his efforts many thousands of lives have been and will be saved, because the surgeons were compelled to adopt this method, frequently against their own will.

It is pleasant to remember and recite at this time, when there is more or less discussion as to what America is doing in the war, that it was an American citizen who made all this possible, and that it was the generosity and far-sightedness of Mr. John D. Rockefeller, in maintaining the expense of the Rockefeller Institute of this city and very largely the Rockefeller Hospital in France, that made possible the elaborate experiments which have resulted in this great discovery.

Then, too, to another American citizen, an American by adoption, Dr. Carrel, who discovered this process, is due great honor and glory; and he had with him others from this country who, in large measure, bore the burden and aided him in making his discoveries and in perfecting his appliances.

And then again, as I said before, there is a third American citizen, who, with his keen foresight, saw some of the great value to humanity of all this work and had much to do in helping to bring about its universal adoption, our distinguished associate, Dr. William O'Neill Sherman. (Applause.)

I think I am telling you something that will please you all, and especially please the Carnegie Steel Co., when I repeat what was said in France—that it was owing to the persistent and unfaltering work of Dr. Sherman, both day and night, in urging that this method become obligatory, more than to any other influence, that has made its adoption possible; and I think that this tribute to this eminent American surgeon is well deserved because I know he has left his mark in France in a way that will be long remembered. (Applause.)

President Gary: I am sure that Mr. Penton's fine tribute will be much appreciated by Dr. Sherman. I know it is by the Carnegie Company and the United States Steel Corporation.

We will now have a paper on Chemical Reactions of Iron Smelting by Walther Mathesius of Chicago.

CHEMICAL REACTIONS OF IRON SMELTING

Walther Mathesius

Superintendent of Blast Furnaces, Illinois Steel Company
South Chicago, Ill.

Throughout the Middle Ages, and as late as the first half of the nineteenth century, blast furnaces were operated the world over with the utmost secrecy. Those skilled in the art carefully guarded their knowledge, surrounding their work with a veil of mystery and handing it down from father to son as a precious tradition.

The first attempt of science to invade this magic circle was, as far as I know, made by Robert Bunsen, who, in 1839, investigated the operation of a little charcoal furnace in connection with his fundamental work on the development of methods for analyzing gases. Since then experimental and operating data relating to the blast furnace process have become available in goodly numbers and a multitude of theories have been advanced, based on such information. In many instances, theories have also been advocated which unfortunately did not have the foundation of such actual experience. In this way volumes have been written, but by far the largest portion of these efforts have been of an explanatory nature, exploring into features of operation which had previously become established through practical experience. Thus it may be stated that, up to the present day, the operating man is still leading in the race between the blast furnace theory and practice, and it need not surprise, therefore, that even to-day blast furnace theorists are being looked upon by some practical men with a certain lack of esteem.

There are still many adherents to the creed that blast furnace progress must be brought about through practice, leaving it to science to afterwards explain the "whys and wherefores." Men of this type overlook the fact that, since the introduction of hot blast, when explanations were sadly

lacking for the startling improvement wrought thereby, science has made gigantic strides to close the gap between actual results and their theoretical understanding. The existence of this gap has afforded in the past splendid opportunities for harassing the blast furnace with schemes the futility of which, while theoretically apparent, still had to be proved and paid for by failure in practice. So, as the day draws near when the scientist will wring from the blast furnace its last mystery and will mark it down with mathematic exactness, the theory of the blast furnace process demands of the furnace operator more respect and attention than ever before. While he may not care to follow all the intricate lanes of research and experimentation that have led to the present knowledge, he should have a thorough understanding of the process with which he deals, and it is from his standpoint that I intend to review the reactions of iron smelting as carried on in the blast furnace of to-day.

The task of the blast furnace, while performed as one continuous and interlocking process, may be divided into physical and chemical duties. Among the former the principal items are:

(A) The drying and preheating of the burden materials.
(B) The melting and superheating of the resultant iron and slag.

The chemical duties comprise chiefly the following:

(C) The calcination of the carbonates.
(D) The reduction of the metallic oxides of the ore burden.

The relative importance of the physical and chemical work may be best judged by comparing the amount of energy consumed by each. This can readily be calculated by establishing a heat balance.

An average taken from a number of such calculations covering modern operations shows that, of the total heat introduced into a blast furnace and generated therein, approximately 25 per cent. is sufficient to take care of the above-mentioned physical duties, while the chemical reactions require about 60 per cent. of the total, the balance

being absorbed in radiation losses and heat escaping with the gases. These figures gain particular interest when considering that it is the physical part of the blast furnace work only that is immediately accessible to observation and measurement. It will also be readily understood that any improvement or deterioration in the chemical work must affect the furnace efficiency as a whole to more than double the extent than would a change of equal magnitude in the physical or melting operation. Economy in the performance of the chemical reactions is, therefore, of prime importance to the blast furnace man.

By far the largest part of the blast furnace chemical work consists of the reduction from the ores of the various constituents forming the pig iron. The reducing agent, to bring about this transformation, is furnished by the fuel. From the total amount of coke which is charged into the blast furnace, a certain percentage is always carried out by the furnace gases as coke dust, and another portion is dissolved by the pig iron. At plants using similar raw materials, and under normal operating conditions, the sum of these two items varies only within narrow limits and amounts to a small percentage of the total. It does not decidedly influence the general efficiency of the furnace operation, for which the fuel consumption is the most generally accepted criterion. The latter depends almost exclusively on the mode of gasification and utilization of the remaining major portion of the carbon in the coke. The possibilities in this respect are:

1. The carbon, having passed downward through the furnace stack, reaches the hearth and is gasified there either by:

(a) Combining with the oxygen of the blast at the tuyeres, or

(b) Combining with the oxygen of metallic oxides (direct reduction).

2. The carbon does not reach the hearth, but is gasified above the hearth by reacting with the CO_2 of the furnace gases (premature combustion).

The reactions classed under 1 are normal operating necessities. The reaction (a) creates heat and reducing gas (CO); the reaction (b), while consuming heat, furnishes reducing gas and pig iron product. As long as their sum-total and their relative proportion remain within proper limits, these reactions must be classed as desirable, while an excess of either one is superfluous and detrimental.

The reaction named under 2 produces, at a loss of heat, reducing gas only, which, if at all required in the operation of the furnace, could be more advantageously furnished by either reaction 1(a) or 1(b). The premature combustion of carbon must, therefore, in all cases be considered a detrimental reaction.

All three of these reactions have one thing in common. They produce carbon-monoxide, the agent by means of which by far the largest portion of the metallic oxides in the furnace burden is reduced to metal. This process, for which the equation $Fe_2O_3+3CO=2Fe+3CO_2$ may serve as an example, is known as "indirect reduction." Its economy is in a large measure responsible for the remarkable efficiency of the blast furnace, which to the present day has not been surpassed by any other metallurgical process.

To substantiate this statement, and to answer several arguments brought forth lately disputing the superior efficiency of the "indirect" over "direct" reduction, the following comparison should be made:

(1) Indirect Reduction:

$Fe_2O_3+3CO=2Fe+3CO_2$

Thermal value = +426 B.t.u. per lb. of carbon.

and $FeO+CO=Fe+CO_2$

Thermal value = +351 B.t.u. per lb. of carbon.

(2) Direct Reduction:

$Fe_2O_3+3C=2Fe+3CO$

Thermal value = −5406 B.t.u. per lb. of carbon.

and $FeO+C=Fe+CO$

Thermal value = −5481 B.t.u. per lb. of carbon.

(Thermo-chemical data from J. W. Richards' "Metallurgical Calculations.")

It can readily be seen that, from the thermo-chemical standpoint, the indirect reduction, showing a slight gain of heat, is decidedly superior in efficiency to the direct reduction, with its very material loss of heat. But also with reference to carbon consumption, the indirect reduction has the advantage. While, for the same amount of iron reduced, the carbon requirement is the same in both cases, the indirect reduction utilizes carbon in the form of CO, while the direct reduction consumes carbon, which could be used to better advantage for the generation of heat by burning it to CO with the oxygen of the blast at the tuyeres.

The equations illustrating the comparison of indirect and direct reduction has also been written as follows:

$$\text{Indirect:}\quad Fe_2O_3+6CO=2Fe+3CO+3CO_2$$
$$\text{Direct:}\quad Fe_2O_3+2C=2Fe+CO+CO_2{}^*$$

and on the basis thereof it has been stated that, as regards carbon consumption, "direct" reduction was three times as efficient as "indirect" reduction. The errors of this line of reasoning are obvious. There are three molecules of CO introduced into the first equation which are by no means essential for the carrying on of the reaction, in which they are taking no part. The second equation shows as one of the products of the direct reduction, carbon dioxide, which cannot possibly exist in the presence of carbon at temperatures necessary for the direct reduction. Even if carbon dioxide were momentarily produced, it would instantaneously be converted back into carbon monoxide, and in doing so require the additional molecule of carbon, which thus is actually consumed in the process of direct reduction.

Thus it is evident that, from a standpoint of economy, the indirect reduction is more desirable than the direct reduction. The latter is economically permissible only under the following conditions: First, where indirect reduction cannot take place—for instance, when oxides to be reduced are not accessible to furnace gases; and, second, in case the combustion of carbon by the oxygen of the blast at the tuyeres does not furnish sufficient carbon

* J. W. Richards, "Metallurgical Calculations," pages 252, 253.

monoxide with which to properly take care of the indirect reduction.

Direct reduction, as mentioned first, takes place in every furnace and is a function of the composition of the iron; in other words, the percentage of silicon, phosphorus, manganese, etc., to be reduced and of the percentage of burden materials, the metallic contents of which are for physical or chemical reasons not affected by the reducing action of the furnace gases. With these conditions given, this phase of direct reduction can be considered as practically constant.

The other case of direct reduction, which is due to scarcity of CO from combustion at the tuyeres, is most likely to be incurred where furnaces are burdened with ores that are easily reduced, and where such furnaces are operated at a fast rate of driving, with high-blast temperatures. Under such conditions, direct reduction will take place to a greater extent the lower the percentage of silicon is in the pig iron. Modern Mesaba practice on basic iron is a good example.

The possibility of a deficiency of reducing gases under the conditions mentioned has frequently been disputed; the chief argument brought forth has been that in furnaces of this class the ratio of CO_2 to CO in the top gases is almost without exception considerably lower; or, in other words, the top gases have a greater reducing power than appears necessary according to the well-known curves of equilibrium as established by Baur and Glaesner. While this is true, it should not be overlooked that the data used as basis for these curves are the results of laboratory experiments with sufficient time allowed for any and all reactions to run through to completion.

Comparing, on the other hand, the volume of gases generated at the tuyeres per minute with the cubic contents of the furnace, and considering at the same time that the stack is not empty but filled to the top with ore, stone and coke, that therefore the only spaces available for the furnace gases are the voids between the solid particles, it is apparent that the time during which the volume of blast entering through the tuyeres can possibly remain in contact

with the furnace burden is, at best, only a few seconds. This short interval is all that is available for each molecule of gas to undergo the various reactions which take place between the oxygen of the blast or ore and the carbon of the coke, between the resultant CO and the metallic oxides of the ore and between carbon dioxide and the carbon.

It is evident, therefore, that the extent to which the various reactions will perform within the blast furnace depends to a large measure upon the reacting speed of which they are capable. The speed of any chemical reaction decreases the closer the relative quantities of the reacting and resulting substances approach the status of equilibrium. Therefore, the various reactions cited above will, within the limited time available in the blast furnace, take place to a larger extent the farther away the relative quantities remain from the status of equilibrium. In other words, in order to be reducing to a degree sufficient for actual practice, the furnace gases must be richer in CO than would be expected from the experimentally determined diagram of Baur and Glaesner.

Thus the possibility of a modern furnace being insufficiently supplied with carbon monoxide through the combustion of carbon at the tuyeres is by no means remote. It is incurred particularly where, with easily reduced ores, high blast temperatures are used, because with higher blast heat the generation of the necessary quantity of heat in the hearth requires less carbon. Theoretically, and keeping strictly within the boundaries of Gruner's theory of the ideal working of a blast furnace, this condition should be remedied by lowering the blast temperature and burning more carbon at the tuyeres. Otherwise, ore must reach the hearth without being properly reduced by the gases, there to be reduced by solid carbon, with a consequent loss of heat to the hearth.

In modern practice this question is solved differently and more economically by permitting direct reduction to take place and at the same time off-setting the entailing heat loss by raising the blast temperature. The limit to which this direct reduction can be carried on depends on

the ability to offset the resultant heat deficit in the hearth by higher blast temperature, and on the necessity to keep the top temperature above the desired minimum which is essential for the timely drying and preheating of the ore charges preparatory to their reduction by the furnace gases.

The results obtained may briefly be summed up as follows: Without raising the volume of wind blown, the amount of carbon gasified in the hearth and the weight of metallic oxides reduced per unit of time is increased. The furnace operates at a higher rate of output without requiring additional coke for its hearth reactions. As the cooling and radiation losses per ton of iron are inversely proportional to the rate of production, a saving is effected in this respect, which must ultimately find its expression in a lower coke consumption. As part of the coke carbon is gasified by oxygen from the ore without the addition of nitrogen from the blast, the amount of gas per unit of burden material charged becomes less. The initial temperature of the gas leaving the hearth not being changed, this results in a lower top temperature as well as a lower temperature of the stack. The beneficial effect of this drop in stack temperature on coke consumption and on furnace practice in general will be dealt with later.

Incidentally it may be said that this line of reasoning offers a very plausible explanation for the quite frequently observed fact that in Mesaba furnaces, where high blast heats are available, the burdening of certain percentages of materials not affected by the reducing influence of the furnace gases, such as sinter, results in benefits as mentioned.

Being an endothermic reaction, all direct reduction has frequently been considered detrimental. In reality this can apply only to an excess of direct reduction beyond the limits as outlined above. From the same point of view, direct reduction in the hearth has often been confused with direct reduction in the stack, which more correctly should be termed "premature combustion." The latter consumes coke carbon before it reaches the hearth by attacking it and dissolving it in carbon dioxide in the upper regions of the furnace according to the equation $CO_2 + C = 2CO$.

Its influence on the furnace efficiency, both thermal and with reference to carbon consumption, is the same as that of excess direct reduction in the hearth. My previous statement concerning its detrimental character is true the more as in practice premature combustion takes place at the highest rate when any addition to the carbon monoxide content of the gases is least desired.

At temperatures below 900° to 1000° C., premature combustion does not take place to any appreciable extent, as can readily be seen from the curves of equilibrium established by Bondouard. Since its reacting speed grows rapidly with rising temperatures, it is evident that premature combustion must take place in the furnace stack at an increasing rate the higher the temperature of the zone in which the carbon dioxide and the coke come into mutual contact and the longer they remain in contact with each other at temperatures above 900° C.; that is, generally speaking, the higher the average stack temperature of the furnace happens to be. Thus it occurs to a large extent in furnaces making high silicon iron, or furnaces operating on a highly refractory burden, for instance, of magnetite ores. Under such conditions, carbon monoxide is produced over and above the already existing abundance, which has resulted from extensive direct reduction, and which cannot be used to any advantage in the furnace.

In furnaces producing low silicon iron and operating on an easily reduced ore burden, premature combustion may also assume serious proportions, where the rate of driving is too slow and the time is thus unduly prolonged during which carbon dioxide remains within the regions of high temperature in contact with coke. The apparently logical means of counteracting this condition is "faster driving." In many cases this can only be practiced after a change in the quality of coke has been brought about.

I refer especially to the combustibility of the coke, the importance of which was first emphasized and termed by Mr. H. A. Brassert in his paper on "Modern American Blast Furnace Practice," read before this Institute in May, 1914. This quality, above all, determines the pace at

which a furnace can be operated. Unfortunately, a change of coke structure which tends to improve its combustibility will in many instances simultaneously increase its vulnerability to the solving action of the gases, so that the benefit reached on the one side may be more or less offset by the deterioration wrought in the other direction.

However, modern American coke-oven practice has made enormous strides towards approaching the apparently paradoxical ideal of a coke which with the highest rate of combustibility would combine immunity from solution in furnace gases. This is accomplished by producing coke with an open-cell structure in which the cell walls themselves are amply strong and well protected by a graphitic coating. The results accomplished in this respect are in a large measure responsible for the remarkable improvement of coke practice which has been obtained at a good number of American blast-furnace plants during recent years.

Among the ways and means which counteract premature combustion and are practiced aside from faster driving, I wish to mention one which is now so universally used that its value is often overlooked. I refer to the use of raw limestone as flux. Realizing that it took a considerable amount of heat to calcine the stone, and in an effort to relieve the blast furnace of this duty, the attempt was repeatedly made in past days to charge burned lime in the place of raw stone, but without attaining the expected improvement.

The explanation lies obviously in the fact that the endothermic calcination of the limestone, which takes place above 900° C., is one of the most effective means to quickly bring about a cooling of the furnace gases below the zone of temperature where premature combustion can take place; it appears that thereby, and by simultaneously preventing premature fusion of the ores, which would place the latter beyond the reach of indirect reduction, more coke is preserved and made available for the generation of heat at the tuyeres than is necessary to furnish the heat required for the calcination of the stone.

Since the direct reduction, where practiced within

economical limits, increases the ratio of burden to furnace gases, thereby lowering the average stack temperature, it, too, may be termed an effective antidote against premature combustion.

Another most effective means of preventing premature combustion is the application of high blast temperatures. By thus accelerating combustion at the tuyeres, providing for the heat requirements of the hearth with less fuel and a consequently lower volume of gases, concentrating the zone of highest temperature and increasing the ratio of descending materials to rising gases, a decided lowering of the average stack temperature, with correspondingly better fuel economy, can be and has been accomplished. For instance, the blast furnaces at South Works, Illinois Steel Company, being operated according to these principles, have for a number of years, in spite of a severe handicap in the form of irregular coke supply, not for a single month exceeded a coke consumption of 1,900 pounds per ton of iron for twenty-one consecutive months. During the year 1916, these same furnaces, with an average age of 331,771 tons per lining, produced 2,066,256 tons of iron on an average coke consumption of 1,854 pounds per ton.

From the analysis of the various reactions, it is evident that direct reduction and premature combustion in reference to origin, performance and prevention are two distinctly and entirely different processes, each one independently playing its own important part, in widely varying degrees, in every furnace operation. The only common tie between them is their endothermic character and the fact that they both consume carbon. The sum-total of their carbon consumption represents what is usually called the amount of carbon gasified above the tuyeres. As this carbon is consumed partly by economical and partly by wasteful reactions in ever-varying proportions, it is evident that the relation of this total "carbon gasified above the tuyeres" to the fuel consumption of a furnace cannot possibly have a direct bearing on the economy of the furnace operation.

These relations have until quite recently remained obscure, because it was considered impossible to separately

calculate direct reduction and premature combustion, while their combined total could be obtained with comparative ease by either subtracting the weight of the carbon gasified at the tuyeres from the total carbon gasified in the furnace, or by directly using the following mathematically developed and therefore universally applicable formula:

$$C_x = \tfrac{3}{4} O_e - \frac{7m}{11+7m} (C - C_{Fe}) + \frac{11}{11+7m} C_{ez}*$$

in which

- C_x means the amount of carbon gasified above the tuyeres,
- O_e the oxygen contained in the metallic oxides of the burden,
- m the ratio by weight of CO_2 to CO in the top gases,
- C the total weight of carbon charged,
- C_{Fe} the weight of carbon absorbed by the pig iron, and
- C_{ez} the carbon contained in the CO_2 of burden and flux.

To cite in detail the method of dissecting this "C_x" into its constituents, direct reduction and premature combustion, is beyond the scope of this paper Suffice it to say that it is done by establishing separate balance sheets for the hearth and stack with reference to heat as well as materials, and therefrom determining the theoretical top temperature for varying percentages of the two constituent reactions involved.† The light which this method of calculation is able to throw upon the economics of furnace operations would seem to justify the belief that it is the solution for the most complicated of blast-furnace puzzles.

To complete this review of blast-furnace reactions, I wish to mention one which in modern furnaces appears only occasionally to any extended degree. This is the

* Professor W. Mathesius, "Investigations Concerning the Blast Furnace Process" ("Untersuchungen ueber die Vorgaenge im Hochofen"), Stahl und Eisen, 1913, page 1467.

† Professor W. Mathesius, "Die physikalischen und chemischen Grundlagen des Eisenhuettenwesens." Spamer, publisher, Leipzig, Germany, 1916.

decomposition of carbon monoxide according to the equation $2CO = C + CO_2$.

As the speed of this reaction is comparatively low, on account of the existing ratio of quantities involved, and since the zone of temperatures within which it can take place is limited to approximately from 400° to 600° C., the extent of this reaction is, as a rule, slight. Theoretically it must be classed as economical, being exactly the reverse from "premature combustion." However, in practice, when this reaction takes place to any considerable degree, serious difficulties are encountered which make it extremely undesirable. The resulting carbon is deposited on the ores in a very finely divided form and interferes with their permeability to the gases, clogging the voids and causing a swelling of the charges, scaffold formation and all the serious troubles which follow.

When fine Mesaba ores were first used in larger percentages, such difficulties due to excessive carbon deposition were experienced more frequently. With furnace lines poorly suited for the smelting of these fine ores, particularly with the flat bosh angles then in use, irregular working of the furnace with protracted periods of hanging were nothing exceptional. The movement of the furnace charges being brought to a standstill for considerable periods of time, a much larger percentage of the materials in the upper part of the furnace stack was heated to a temperature where decomposition of carbon monoxide could take place, with a corresponding increase in the extent of this reaction as the result. Since then, however, furnace lines have been improved to such an extent as to make operating difficulties from this source a rare exception in Mesaba practice.

It has been observed, too, that a high percentage of hydrogen is often present when carbon is deposited in this manner. The reducing power of hydrogen relative to that of carbon monoxide increases with falling temperatures, and it is reasoned that, with a high percentage of the former, metallic iron in finely divided form is reduced from the ores at exceptionally low temperatures; this metallic iron then

acts as a catalytic agent which greatly increases the reacting speed of the decomposition of carbon monoxide.

Excessive hydrogen in the top gases to an extent necessary to bring about such a condition is generally the result of defective apparatus, such as leaky hot-blast valves, tuyeres and bosh plates. If this be the case, the undesirable deposition of carbon can be overcome by removing the source of the hydrogen.

From the standpoint of an operating man, I have attempted to give a brief outline of a subject about which volumes have been written by men of science without ever covering the field. To them belongs the task of further theoretical exploration. We blast-furnace operators must be ready to apply and prove in practice. (Applause.)

President Gary: I cannot help feeling that the Illinois Steel Company's furnace department is a pretty good proposition.

This paper will now be discussed by Mr. Henry P. Howland, of the Wisconsin Steel Company.

THE CHEMICAL REACTIONS OF IRON SMELTING

DISCUSSION BY H. P. HOWLAND

Superintendent Blast Furnaces, Wisconsin Steel Company, South Chicago, Ill.

Mr. Mathesius has presented a paper which blast furnace operators will do well to study and to put into practice. The tendency of American blast furnace men is to give too little emphasis to the technical side of their profession. While I do not agree with the author in all his conclusions, he has certainly covered the ground admirably. What I wish to do is to mention briefly and simply the more interesting points in blast furnace theory.

Let us remember that practically all of the scale, scrap, iron and steel in the world to-day had, as its first step, to be produced in the blast furnace. All of our principal iron ores are a chemical combination of iron and oxygen. The function of the blast furnace is to deprive the ore of its oxygen and then to melt the remaining iron. You will note that Mr. Mathesius' article deals entirely with the reactions between the carbon of the coke on the one hand and the oxygen of either the air or the ore on the other hand. It is impossible for us to change the quality of the oxygen in either the air or the ore. We have, however, learned by sad experience that we change both the quantity and quality of the carbon in the coke.

The existence of the blast furnace depends upon the simple fact that a large enclosed body of coke cannot be burned by air to CO_2 (carbon dioxide). To state it another way, if we have a furnace full of coke only, the gas coming from the furnace top would contain carbon gas, only in the form of CO (carbon monoxide). This CO is in search of another atom of oxygen and it is the business of the blast furnace to satisfy this desire by introducing iron oxide Fe_2O_3. As the iron ore introduced at the furnace top works downward through the rising current of CO gas, most of it loses its oxygen, thus becoming Fe ready to be melted in the

hearth. This reduction of Fe_2O_3 by CO is termed "indirect reduction."

The problem of blast furnace efficiency is to bring as much as possible of the iron ore and CO into intimate contact. This results in a minimum of CO leaving the furnace without having met some of the iron ore, and also in a minimum of the iron ore getting down into the furnace hearth without having lost its oxygen to the CO.

When the iron oxide does get down into the hearth there is only one thing that can happen, namely, the oxygen must be removed by means of unburned carbon, or as we term it, "direct reduction."

Mr. Mathesius has brought out very clearly the relative values of the indirect and direct reduction with regard to both the amount of carbon required and the heat consumed. The amount of carbon required depends upon the way the equations of reduction are written. There is some difference of opinion along this line and I am one of those who would write the equations differently from Mr. Mathesius. We do agree, however, upon the positive value of direct reduction as stated by him.

The fact that the direct reduction of iron oxide by carbon takes place in the hearth and that this reduction absorbs a great amount of heat tends to make the hearth cold. It is interesting to note in this connection the similarity between the human being and the blast furnace. A furnace with hot top and a cold hearth is exactly in the same need of treatment as a man with a hot head and cold feet; in other words, we have the well-known term—a sick furnace. The treatment consists in getting the furnace hearth hot, either by using hotter air blast or additional coke, or better still, a better quality of coke. To quote Mr. Mathesius, "The limit to which this direct reduction can be carried on depends on the ability to offset the resultant heat deficit in the hearth by higher blast temperature." I would state this differently, by placing more emphasis upon the quality of coke. In other words, unless we have a coke of good quality it is practically useless to attempt to supply the heat loss due to direct reduction by the application of high blast heats.

A good coke will burn instantaneously to CO, creating the heat in the hearth where it is needed. The gases generated in the hearth require but a few seconds to pass through and out of the furnace and unless the CO is made in the first fraction of a second, the heat may be produced where it is almost worse than useless.

Mr. Mathesius illustrates the value of his theories in general and the application of high blast heats in particular, by citing the remarkable record made at South Works for the year 1916—over 2,000,000 tons of iron with an average coke consumption of 1,854 pounds of coke per ton of iron—certainly a most wonderfully remarkable record.

At the plant of the Wisconsin Steel Works we have a furnace which has given remarkable results, though on lower blast heats. It is the work of this furnace that has convinced me of the supreme value of a highly combustible coke.

The furnace was blown in in August, 1914; the production is as follows:

Monthly average	17,300 gross tons
Year, 1915	211,700 gross tons
Year, 1916	208,100 gross tons
Total for the blast to May, 1917	553,000 gross tons

The coke per ton of iron for the blast to May 1, 1917, as actually charged to the furnace, based upon railroad scale weights at the ovens several hundred miles away, is 1,703 pounds. Included in this is about 3 per cent. screened out at the pockets, but charged to the furnace.

As Mr. Mathesius points out, the prime qualifications of a good coke are: first, its ability to resist the destructive action of CO_2 in the top of the furnace, and, second, its ability to burn instantaneously in the hearth. It so happens that these two requirements are, as he also points out, diametrically opposed. All the coke burned by air in the hearth is first burned to CO_2 but immediately broken up into CO by the reaction $CO_2 + C = 2\ CO$, due to the intense heat of the hearth. In other words, for a good coke we require one which as it works its way down through the furnace will refuse to have anything to do with CO_2, but when it finally reaches

the hot hearth it will immediately be consumed by CO_2. A good deal to ask of an ordinary piece of coke. However, this is the kind of coke we have been producing at many of our coke plants in the past few years.

The advance in blast furnace practice in recent years is, undoubtedly, due to two principal items: primarily, a coke conforming to the requirements stated above, and, secondarily, better furnace lines.

In concluding, we wish to express our appreciation of Mr. Mathesius' presentation of this rather involved question so important to the blast furnace industry and to express the hope that before long we may again demand of our coke supply, quality first, rather than quantity. (Applause.)

PRESIDENT GARY: Adjourned until seven o'clock this evening in this room.

ANNUAL DINNER OF THE AMERICAN IRON AND STEEL INSTITUTE, WALDORF-ASTORIA, NEW YORK, MAY 25, 1917.

EVENING SESSION

The evening session of the Institute was held in the Grand Ball Room of the Waldorf-Astoria. After the dinner, the President, Judge Gary, called the meeting to order and said:

I suggest that those who are now seated farthest away from this table, so far as practicable, move up toward the front. It may be somewhat difficult for you to hear from the distances you are now occupying. You can bring your chairs up with you. (Pause while the suggested changes were being made.)

I remember at one of our banquets, when the meal was a good one and a long one, all who were in the hall were in good spirits and making considerable noise up to the time when we were ready to hear from the speakers, but at a suggestion that it would be necessary to have perfect quiet in the room in order to hear, and the further suggestion that the galleries were occupied by ladies, the house immediately came to order, and from that time on there was perfect silence. Some one asked me how it could possibly be done so thoroughly and so suddenly, and I replied that it was because the steel men are all gentlemen. (Applause.) Having been placed on that pinnacle, I hope all of us will live up to our reputation this evening, and that notwithstanding the immense crowd we may have perfect quiet.

You know at the beginning of this war a temperance movement was started, perhaps in Russia, but anyhow it extended throughout the countries actually engaged in the conflict, and since that time there has been very little liquor drunk throughout Europe. Besides the influence of that example, we have at the present time in New York City a man who has thoroughly stirred the community, and New York City has partly become a temperance town because of "Billy" Sunday. (Applause.) We have very little, if any, wine on the tables this evening. And just to prove that we can drink a toast without having wine, I am going to ask

you to take whatever is on your table in the shape of liquid and rise and drink to the President of the United States.

(The entire audience rose and drank to the President. Then the lights were turned out and a spot-light was turned on a large American flag which was seen to be waving in the breeze of an electric fan near one end of the speaker's table. Accompanied by the orchestra in the gallery, the audience joined in singing the Star Spangled Banner. The scene was an inspiring one, and at the conclusion the entire audience burst into hearty applause.)

President Gary: The gentleman I am going to call upon first has such complete control of the food situation in this country that we are hoping—nay expecting—that within a short time we shall have upon our tables bread, and quite possibly potatoes, and even beans. It is my pleasure to introduce Mr. George W. Perkins of New York. (Applause.)

Mr. Perkins: One would think from Judge Gary's introduction that I at least knew beans when the bag was opened. I doubt it so far as the food situation is concerned, and I am sure any of you would doubt it if you had been in close touch, as I have been in the last two or three years, with that subject here in New York.

My son, who was home for a day or two last week, when I told him that I had to be away that evening to make a few remarks at a dinner, said: "Dad, I heard yesterday a new definition of a gentleman." I thought I would take my chances, and asked him what it was, and he said, "A man who is sure he can play a violin, but refrains." (Laughter.) I had a good notion to call up our very worthy secretary and withdraw my acceptance to the invitation to speak for ten minutes this evening.

This Institute, it seems to me, stands to-day for a very great opportunity in the reorganization and the forward-looking policy that business must adopt in this country if the United States is to take anything like a first place, a leading place, in the industrial activities of this world when this war shall have been concluded. There has been a great

deal said, in the last few months particularly, of the necessity of preparedness, of our unpreparedness, and latterly much activity in the line of preparedness. But it has been largely in preparedness for war at arms, and it has seemed to me for some time—for several years, in fact—that we are as unprepared for war at arms as we are for war in industry. We have taken as little time and made as little study as a people, and as represented through our government, to prepare ourselves for the new world of industry that is opening up, as we have to prepare ourselves for war at arms.

The topic assigned to me is "The Man of the Future." I believe that Bismarck is credited with having said in the latter days of his life that America would prosper and move forward until we had reached the Pacific Coast with our railroad building and the taking up of new land; that when that time arrived, we would, in his judgment, meet our supreme test. How curious it is that that time has arrived at almost the very hour when we go to war with Bismarck's country.

Now, what did Germany do to prepare herself for the time when her population would be dense, when she would have to compete as a small country in acreage with the great world on all sides of her? The Sherman Law, otherwise known as our Eleventh Commandment (laughter) was adopted in this country as the business philosopher and friend and guide post of our future, and it has been very interesting to me to see what Germany did about that time. Almost at the very time we adopted the Sherman Law, Germany entirely discarded the idea of intensive competition and began to develop the idea of co-operation, and no men in this country know better than you how consistently and successfully she has carried out that policy at every turn, whether it has been in the steel business or any other business or in her scientific or governmental policy—it has been one continuous movement forward along co-operative lines. The consolidation of every interest, the heading up to one centralized body that every particle of waste might be eliminated and the best energy of the country, whether it be man energy or steel, might be devoted to the best use of her

people as a whole. No pains have been spared to bring about that result. During these twenty-five years, on the other hand, we in this country have been doing everything we could, by law and by agitation, to take exactly the opposite stand.

In my judgment when this war is over it is going to be a question of whether these United States, that we have been so proud of and felt is unsurpassed, whether this country is to be the new world or the old world. During the last three years the attention of the entire world has been of necessity rivetted on the efficiency of Germany. We have all studied her methods to discover what has made it possible for one small country in acreage and a population of no vast numbers to practically stand off the world in a great war.

The answer, of course, is her efficiency in every direction. Now, when the war is over, be the end what it may, the German people are still going to be there. In this war they have been schooled more severely than ever in the lesson of self-sacrifice for the benefit of the people as a whole. England will have learned much of that theory and that practice, and so will the rest of the world. Now, if we are going to stand by and say that, nevertheless, we are going to insist on doing business as our forefathers did; if we think more of a law written twenty-five years ago than we do of any changes that may make it necessary to write a new law—then we shall be faced with the question of whether this shall really be the old or the new world.

For several years I have been having my say on why the conditions that exist in this country do exist, but I am going to keep on saying it in some form or other before every audience that I have the honor to address. My belief is that the business men are largely to blame. We have been chasing the almighty dollar to the exclusion of everything else. In 1860, when our last great war was fought, the question up to that time was whether this was to be one country or several, one currency or many, one tariff or a number. People were in doubt. That war settled the question. This was to be one consolidated country. We were to go on and

develop into a great nation composed of a number of subsidiary nations. That period opened up to men of first rate ability opportunities that had never existed before. Curiously enough, just as those questions of statesmanship were settled, the inventor began his work, and the invention of methods of inter-communication have been marvelous, as you know. Those inventions have turned the world into one small unit. Before this war broke out, we did not think much of the airship or the submarine, but the war has given new impetus to these new methods of inter-communication, both of the voice and of the commodities. With that impetus added to what we had before, how necessary it is for us as a nation to learn that we must get on together and do business as groups rather than as individuals.

The period of individualism, as such, has passed. In this war it is making its exit throughout the world. I do not mean by that that the individual has passed; that individual initiative and effort and the necessity of men of fine parts and great ability as leaders has passed. Not at all. But I do mean that these men must come to realize that their chances are given to them not simply to make money for themselves, to acquire power that money gives for themselves, but that these talents are given to be used for the benefit of humanity as well as for themselves. Now, we business men know that that has not been our practice. We have been absorbed in the greatest game of money making that the world has ever witnessed, and we have neglected our public duty. One needs only to go to a capital like Albany, where I have been several times this last winter on food legislation and other matters, and go to our national capital and look at, to say nothing of conversing with, the representatives from our local counties at Albany, or our congressional district at Washington, to realize that a cog has slipped somewhere, because we have not sent to those legislative bodies, to put it mildly, the very highest type of citizenship that our community can offer. (Laughter.) We are facing a very great crisis, and if we have not got in public office the kind of men we should have, it is our own fault, gentlemen.

I was at a small dinner a few nights ago. Those present were talking about the conditions at Washington, and one man, whom I supposed to be a dyed-in-the-wool reactionary, amazed and interested me very much by saying to the men around the table that we are to blame. Then he said, "I will lay a wager that there is not a man at this table who knows the alderman from his ward." And he proved to be right. I do not know that it was especially to the discredit of any gentleman at the dinner that he did not know his alderman (laughter) but we did not. He moved on up. He asked for one who knew his representative at Albany, either in the Senate or in the Legislature, and none of us did. He asked if any man there knew his congressman, and there was not a man who knew his congressman.

In times like these that seems almost incredible, but that has come from our almost entire neglect of our duty in such matters. Now, we are facing changes in our whole fabric, as I have said; the change that has come through the war, the change that has come to our industry because of the war. If we are going to come out of this whole situation with the place that America ought to have, it seems to me that we have got to use all the influence and ability that we, as business men, have, to let such men as now represent us in our legislative body realize that we have come to life, that we propose to be in touch with those men and hold them responsible for the manner in which they shape the destinies of this country. It is the least that we can do. It is all easy enough to take a war bond and do that sort of thing, but that is not going to get us out of our present difficulties.

Yesterday I was in Washington talking with Mr. Hoover and other people there about the national food problem, and I found that the same influences are at work in Washington to prevent any sort of constructive work in the solution of our food problem that have been at work in Albany. In other words, a consistent program is being carried on to prevent any sort of group-work anywhere in solving the food problem. In a city like this, where there is so much at stake in the matter of our food, there is no officer in power

to represent the people or in any way help them in that problem, while there are officers for every other sort of activities. Yet the matter of food in this country to-day, from the information that the committees with which I am connected have gathered, is of the gravest possible concern. Most of you know that our wheat crop will be short—very short—probably as short as any crop we have had for twenty-five years, but probably few of you know that in this state there are to-day 75,000 fewer yearling cattle than there were last year, and I know that in most parts of the state calves four to six weeks old are being killed. Indeed, many people in the rural districts have written to us that their observation is that no calves are being saved, because the price of the meat is so high and the price of the milk to raise them is so expensive. Most every form of animal life is being sent to the slaughter house, even those still carrying their unborn young. So that the problem is not what will happen to our poor communities in the next two or three months, but what will happen next winter or in the next year, for you cannot grow animal life in the next few weeks or months, as you can vegetables and that sort of thing.

I know you men to be men who think and reason and then act, and that is what this situation needs. You know your senators and representatives in Cóngress and I urge you to take the civic problems very deeply at heart and discuss them with the men that represent you at Washington, because no other method, in my judgment, will enable us to right-about-face on the problems of our industrial life—the men at Washington being there for two or more years—except to create in the minds of those men the feeling that you are onto their job.

I was invited to speak ten minutes, and I am sure I have exceeded that time. "The Man of the Future." If I were going to sum it all up, I might have done it in half a minute. I could have told the story, I could have said all that I have said and much more and said it in a more striking and convincing way, if I had said simply that the man of the future to succeed, to serve his interests in business best, to the better relation of labor and capital and solve their problem, to

discharge to the stockholder the highest order of stewardship, to be to his country what a business man should, that man of the future would, in my judgment, be of the type of the leading man of the steel business of the world to-day—our President, Judge Gary. (Great applause.)

PRESIDENT GARY: I have received to-day a telegram from our friend, Mr. Charles M. Schwab, sent from White Sulphur Springs, which I will read:

I am exceedingly sorry that ill health prevents my attending the meeting of the Institute this year. I regard this meeting as the most important one the Institute has ever held, and hope all our members will realize how important it is for all of them to give their best efforts to help supply our government with its requirements of steel during this great period in our national history, and I know all the iron and steel people, members of our Institute, will enter into this patriotic duty with the same enthusiasm and spirit that have made possible this great industry in the past. My kindest regards to all. (Applause.)

By the time the program is finished this evening, most of you, perhaps every one here, who is acquainted and has been acquainted with our membership will think to himself that, notwithstanding all the good speeches we have heard, nevertheless we miss one who was always faithful in attendance and who was eloquent in his addresses and who was loyal to our interests, one of our best friends, whose death we mourn, Mr. James H. Hoyt. I have asked Mr. Willis L. King of Pittsburgh to speak briefly on this subject.

MR. KING: Mr. Chairman and Gentlemen of the Institute: We read almost daily of the thousands and tens of thousands killed in the great war, and although unseen by us and away in a far country, the solemnity and grandeur of their sacrifice for the cause of right and humanity thrills us to the depths. And so it should. For what greater can any man give? Yet, I have in mind to-night a man, not a soldier but one who did his part well in life as a good citizen, a patriot and a faithful member of this Institute.

Since the St. Louis meeting, where he last spoke to us, James H. Hoyt has passed over the great divide. His kindli-

ness, his wit, his wisdom always at our service, are now but a fragrant memory, but he has left a heritage in the records of this Institute which future generations of our members may share with us who have had the good fortune to know him.

As a tribute of respect and in loving memory of this man, to whom we are and always will be debtors, I ask the members of this Institute to rise and stand for a moment in silence.

(The entire assembly rose.)

President Gary: We shall now have the pleasure of listening to Mr. John A. Topping, who will speak on the subject: "Co-operation and the Mobilization of Public Sentiment."

Mr. Topping: The President of the United States in his appeal to awaken the nation to its responsibilities urged that "we all speak, act and serve together" in response to our country's call. The President's appeal met a quick response from business, as evidenced by the mobilization of our financial, industrial, transportation, telephone and telegraph facilities, but our young men made a disappointing response to his urgent call for volunteers for army and navy service.

The lack of patriotic enthusiasm suggested by this experience is, I think, probably due to a lack of understanding by many of our people of the responsibilities of citizenship and of our national ideals. We cannot have unity of purpose, in my opinion, without a more thorough conception of individual responsibility; and to awaken this spirit of moral consciousness we must have a broader education of the people. In other words, if democracy as a governing force is to be effective, it can only be made so by qualifying the people through education, or by necessity, for their civic responsibilities. In no other way can legislative initiative be taken from the political demagogue. It required the stimulus and necessity of war to break down the traditions heretofore surrounding the volunteer system, and we are to be congratulated on this result, for we have obtained in exchange equal service, or selective draft, which means that the first

gun has been fired for the principle of co-operation. And I believe the public mind is now in a receptive mood to apply more broadly this principle, not only through the reconstruction period after the war, as is proposed by the Lever Bill for the regulation of commodity prices, but for an indefinite period thereafter, if we inaugurate an earnest educational campaign for general co-operation.

"New Occasions Teach New Duties"

Necessity has originated many of our inventions, but necessity may also become, as in this case, a great educational influence. It must be admitted, however, that the necessities of war are decidedly more urgent than the necessities of peace, and therefore if public sentiment is to be mobilized and educated to a point of demanding co-operation, or other methods for the protection of business after the war, we must now, like England, prepare for peace while engaged in war. Notwithstanding the great responsibilities of war, the problems of peace are also urgent, and it must not be overlooked that war has brought about revolutionary economic changes, and a world-wide readjustment of values must necessarily follow war inflation, although I do not expect to see the purchasing power of the 1914 dollar restored for some time to come, if ever.

The new conditions and new influences now confronting us should be carefully studied, and business men must help solve future problems in a practical way and must not, as heretofore, depend so largely upon academic thought for the solution of practical questions. To impress this view on the public mind, or to accomplish anything, in an educational way, business men must take a more active part in politics, and in this manner curb the influence of the political demagogue, who heretofore has initiated most of the reactionary legislation from which business has suffered.

Co-operation Has Been Adopted Abroad

Co-operation, in my opinion, is the key to the solution of most of our national and business problems. In recognition of this view, co-operation as a principle has been

adopted by the leading nations of the world. Only recently Mr. A. Bonar Law announced in the House of Commons that preferential tariffs as a policy had been agreed to by Great Britain and her colonies, and that hereafter closer reciprocal treaties and co-operative methods would be worked out between them and their allies. England, notwithstanding the burdens of war, through co-operative methods, has so co-ordinated her working forces that she has substantially maintained her maximum over-seas trade and has also so effectually mobilized public sentiment favorable to the protection of general business that it is freely predicted she will abandon in the near future her traditional policy of free trade. England has also closely followed Germany in the policy of encouraging capital combinations for trade, even to the extent of assisting such combinations by Government loans, where necessary, thus recognizing that it requires big business to develop national resources or to successfully promote and maintain industry. The dye-stuff trade is a notable case of this character. While co-operation as practiced by the various governments now engaged in war, as claimed by some writers, may be a "real working of state socialism," I maintain that it is at least enlightened socialism, for through the application of German and English business methods waste is minimized, efficiency and thrift stimulated and productivity increased. Germany not only proposes to continue her past co-operative methods, but also proposes to extend her syndicate operations in the future beyond a mere control of sales, her war experience showing that purchases can also be syndicated to advantage, and furthermore, that capital investment when regulated will avoid unnecessary duplication of plants and thus prevent wasteful competition. I am convinced that we also must adopt co-operation as practiced abroad as a national system; also enter into reciprocal tariffs; and, furthermore, we must co-operate wherever possible, not only at home, but also with all foreign countries who are reciprocally inclined, for the promotion of trade or for the protection of our other interests.

No doubt the objection will be raised that the European

brand of co-operation is socialistic; but this objection, in my opinion, is sentimental rather than practical, particularly if by the application of co-operation we can advance the general welfare of our country. Furthermore, is not evolution by experience preferable to revolution by force; and does not the co-operative experience of the world justify setting aside former convictions born of other conditions?

Some Practical Suggestions

The mobilization of public sentiment by educational processes, however, takes time and we should not delay our efforts to "Wake up America" to the problems of peace and to emphasize the necessity for co-operation. To make this accomplishment practical and possible, constructive legislation of somewhat the following character seems necessary:

First, Amendments to the Sherman Anti-Trust Act to legalize price co-operation, subject possibly to government regulation, to become effective after the war, so as to prevent disorderly liquidation of commodity values during the reconstruction period, to stabilize values thereafter and for the protection of the general public.

Second, Revision upwards of the tariff where necessary to protect home trade against unfair foreign competition; preferential tariff rates, however, to obtain wherever reciprocal trade agreements can be made to our advantage.

Third, A thorough overhauling of our Marine Laws and the enactment of such amendments as will justify and encourage capital to permanently become interested in the operation of over-seas shipping. If proper protection cannot be given capital to justify it engaging in over-seas shipping and to successfully compete with foreign ships without subsidy, then, in that event, we should subsidize American shipping.

The method I would suggest for promoting the necessary preliminary campaign of education for the mobilization of public sentiment favorable to this legislative program would be co-operative publicity, which power is now gen-

erally recognized and recently was employed by the Academy of Political Science in calling a national conference of our leading citizens to publicly discuss and publish ways and means for improving our foreign relations, the object being not only to promote our diplomatic relations, but to extend our foreign commerce. Unfortunately, there are not many business men who are willing to devote their time to public affairs. But does not urgent necessity call for patriotic service in this direction? The Iron and Steel Institute Bulletin as a publicity instrument could be made useful in many ways to assist in this work without sacrificing its general functions, and thus more completely justify its publication, without being subject to adverse political criticism.

Business and Politics Should Get Acquainted

I am thoroughly convinced that no executive or business man, particularly those who are directing the affairs of public corporations, will hereafter fully measure up to his executive or public responsibilities who does not give these questions his most careful thought, and who is not also willing to devote at least part of his time to public service. Mr. Edward N. Hurley, former Chairman of the Federal Trade Commission, stated not long since that what business needed was constructive statesmanship. As to the truth of this there may be great difference of opinion, but that the country's affairs have suffered from lack of constructive statesmanship there can be no difference of opinion, and business organizations should drive home this thought to the public mind in the most emphatic manner.

In a recent discussion of this subject that I had with a prominent Senator, he admitted that one of the great difficulties confronting the nation is that real politics and real business are not well acquainted; that neither fully understands the principles or the motive-power that is driving the other side. Relative to this subject, the editor of one of the prominent magazines also said to me that education must be made to include a more serious study of the relations of law-making and business; that business men

should co-operate with newspapers in giving publicity to matters of public interest, and thus help educate the politician to business needs. Another editor of a leading trade paper stated that there should be co-operation among trade journals on editorial policy in support of general business propaganda. Even Washington, as has been recently remarked, now recognizes the value of co-operation, and of a "Gary dinner" when it is desirable to mark prices down. There is no doubt, I think, that the educational influences of co-operation for war, considered in connection with the government's approval of the principle of co-operation for the promotion of export trade, will finally result in the approval of this principle for the regulation of general business operations. At least, we have made a start in this direction, for now, as one of the Allies, we are fully committed to co-operation for war. And will we not be automatically committed to the general scheme of co-operation after the war as a necessary condition to terms of peace?

Let Us All Enlist for Public Service

I would therefore urge upon all of you to "speak, act and serve together" in the work of mobilizing public sentiment for co-operation, for the prevention of waste, for the conservation of our natural resources, for the encouragement of thrift, and for the general promotion of the public welfare. Let me also urge upon you to enlist for this service now, begin your campaign at home, educate your local Chamber of Commerce to our business needs, urge the co-operation of your local press, and also endeavor to educate your employees, as some employers now do, by the distribution of leaflets on pertinent subjects through the pay envelope, or by the distribution of other literature, to the viewpoint that your interest is their interest. Furthermore, we should impress upon our representatives in both the House and Senate that their co-operation in this general welfare work will hereafter be considered by their constituency as part of their official obligation. As a preliminary step towards educating the employee of foreign

birth in the fundamentals of citizenship, we should also give more active support to the Americanization movement by co-operating with the Y. M. C. A. and your local Boards of Education. As evidence of the practical character of this co-operative work, the Youngstown, Ohio, Americanization Committee reports that 144 foreigners, representing 16 different nationalities, were graduated during this month into full citizenship after passing all the educational tests required.

As both "big and little business" are loyally supporting the government in times of war, "big and little business" should demand loyal support by the government in times of peace, for only by co-operation can we completely co-ordinate our working forces for the protection and advancement of the nation during either war or peace. The Honorable Charles E. Hughes sums up our national situation in these words: "We have got the basis for success; what we now need is the motive-power of unswerving loyalty and a real consciousness of national unity which will fill us with a dominant sense of patriotic loyalty to the United States."

President Gary: We have some very good things coming, gentlemen. Please do not leave unless you have to. Of course, if your folks at home got a promise out of you, I have nothing to say.

We shall now have the pleasure of listening to Mr. Knox Taylor, President, Taylor-Wharton Iron & Steel Company.

Mr. Taylor: Ladies and Gentlemen: I am very glad to have the opportunity of adding a few words of endorsement to the remarks that have been given us on co-operation, both by Mr. Perkins and by Mr. Topping. The very basis of the Republic is co-operation, and it was never more essential than to-day. The war that we have entered into is the biggest task in our history, though we do not begin to realize it, as the Judge told us this morning. We have arrived at our great national strength through co-operation, and to make the best use of our resources and power to win—and we have got to win—we must co-operate as we never have co-operated before.

The big steel companies have offered their services to the government, and the government needs their help to the fullest possible extent, and this is not a time for hesitation or suspicion. Speaking from the knowledge of the small steel company, we are not afraid of the big companies. We have not seen their power abused, and we do not believe their power will be abused. If it were abused, and we were hurt, we would set up a mighty howl that would be heard. And I think that the converse should follow—that when we have not been hurt, our testimony also should be heard. The government needs big things in these days, and it needs big steel companies to do them. The little steel companies have their place, of course, and it is a mighty important one, too; but we are proud of what the big companies can and will do if given the right opportunity by the government, if given permitted full co-operation. The big men are needed, too, and they are no more to be feared than the big steel companies. What a fine thing it is to see some of our captains of industry giving their service as advisers for the help of the administration, and what a mighty good thing it would be if some of them could be taken right into the administrative family and given real authority. (Applause.)

Time was never more precious; days saved now may mean months or years later. Co-operation is a good thing, but it is necessarily built upon action rather than upon advice; and action is built upon authority. Now, we cannot have any of these things unless we have confidence in each other. Government regulation in the hands of able men who understand their business, backed up by authority and with the spirit of co-operation, is beneficial and very much to be desired.

I was very glad to hear Mr. Topping's reference to the work of the Y. M. C. A., for besides the wonderful work that that association is doing in the war camps, it is doing a mighty good work in the industrial field. Its work has broadened very much in recent years and helps very much for better understanding of and with the workmen, and we ought to help that organization as much as we can, particularly in the industrial fields.

The war has brought many vast and permanent changes.

After the war is over, we hope that the world will be a better place to live in. It will certainly be a different place—far different—than it is now. Every gain in sobriety and mutual confidence and helpfulness we should retain. The reconstruction period will need our best thought and best endeavor. We were slow in preparing for war; let us not be slow in preparing for peace. That was brought out very forcibly and very clearly to-night, and I think that Mr. Topping has made a mighty good selection in the three items that he calls for, demanding constructive legislation, and certainly one of the great needs of the hour is ships. I think I would add but one thing to what he has given us, namely, constructive work for land transportation, for certainly it is a mighty close second in its requirements to water transportation—that is, help for the railroads. No matter how busy we are—and the busier we are, the more important it is—we must take the advice that was given us here to-night, and give time to public affairs. Mr. Perkins drove that home, so that we all ought to remember it and act on it, for most of us are very remiss in this respect. (Applause.)

President Gary: It is my pleasure to introduce Mr. Emil Gathmann, Gathmann Engineering Company.

Mr. Gathmann: Mr. Chairman and Gentlemen: I have read and studied an advance copy of the manuscript, and have this evening followed with the greatest interest Mr. Topping's splendid presentation of the urgent necessity for co-operation and the mobilization of public sentiment. A copy of Mr. Topping's paper should be placed in the hands of every public, as well asevery business man in our country.

Distinguished from some of the other nations of the world, where co-operation has long been adopted as a government principle, in our country the leading directors of our various complex industrial and commercial organizations have been without question the pioneers in carrying out successful practical co-operation, and have been years in advance of the nation and the public at large in the mobilization of their many officials and employees in the ranks of active co-operation.

Throughout the business organizations of our country frequent meetings take place at which each person interested is allowed to offer his own opinion or to express the principles referring to the general welfare, not only of the individual community but also by mutual interchange of ideas and information with other communities; this both through the press and otherwise, which unquestionably results in the betterment of the general welfare of the whole people.

As the necessities of our existence were increased and the fields of our imagination were enlarged, active national co-operation has become more and more vitally essential to any people's welfare, even in the normal times of peace. In these times of national storms and stress the mobilization of public sentiment to the necessity of active co-operation in all the various phases of our national as well as in our individual lives, is of the most urgent importance.

The subject, although exceedingly complex in its entirety, may be simplified by suitable subdivision. For example, national co-operation in our food supply will shortly (as reported in the press) be centralized under the directorship of Mr. Hoover, and we can all feel sure, judging from his past performances, that under his direction the mobilization of public sentiment to effect active co-operation in this, our most essential necessity, equitable food distribution, will be obtained.

Several important branches of our national government are in the most urgent need of a similar centralization of authority, directly under and responsible only to the President of the United States, in order to insure active co-operation in the standardization of production and of distribution of manufactured products. I sincerely trust that the authority for the national co-operation necessary for the highest efficiency will be soon granted, as it will save the people untold millions of money and result in their greater welfare.

The big business men of most communities, ably assisted in many instances by the press, are active in conducting a campaign for the mobilization of public sentiment for effective co-operation. The registration of ten million men on June 5th for the selective draft or conscription will be the first time since the formation of our Nation that all the

States and Territories of the Union have co-operated with the Federal Government on work for the latter. The mobilization of public sentiment has made this possible. If the appeal of the Government and of the business powers, who are now doing their utmost to further increase this public sentiment? are insufficient, why not let us have conscription of all the adult people to effect the mobilization of public sentiment. Compulsory attendance at public meetings in our parks, churches and schools on certain weekly days and evenings can be ordered by proclamation, at which a discourse on and discussion of the various phases of co-operation could be made.

We are all, or if we are not we should be, most familiar with and boosters for home community conditions. Baltimore is and has been for some time past a believer in and a booster for practical co-operation. This has been proven by the work accomplished by our industrial survey, the Merchants' and Manufacturers' Association, and by Baltimore's appreciation and assistance in the great work which Mr. Schwab, Mr. Aldred and many others have recently inaugurated in that community. Still what has been done is only a small percentage of what must be accomplished in further mobilization of public sentiment.

The National Government is greatly indebted to the American Iron and Steel Institute, which has done so much to help mobilize public sentiment on the need of active co-operation, and which was first seriously inaugurated in our country through our President, the Honorable Judge Gary, to whom all credit is due. The welfare of all the people would be increased by their adoption of the Iron and Steel Institute's motto—"Right makes Might—Co-operation."

Mr. Chairman and Gentlemen, I thank you. (Applause.)

President Gary: Mr. A. F. Huston, President of the Lukens Steel Company.

Mr. Huston: I have no set speech prepared. I simply wish to make a few remarks. Memories cluster around this place. It was here a series of dinners were held bearing the name of our honored chairman, which have not been fully understood by the public at large, which have generally been

spoken of disparagingly by public men, but which have been of vast benefit to the country at large. With characteristic foresight, our worthy President endeavored nearly seven years ago to promote friendly relations among the countries of Europe, and thus avert the great conflict now raging there, by bringing together here as guests of this Institute the leading iron and steel men of Europe to the number of about thirty. They came from England, France and Belgium, from Germany and Austria, and were entertained for a week, visiting also Buffalo, Chicago, Pittsburgh and Washington. In this room they were entertained at a banquet. It was in this room more than twenty years ago I heard the late President McKinley deliver his celebrated gold speech. Up to that time it was not known where he stood on that question. It was well known where his 16 to 1 competitor stood. The country breathed a sigh of relief after that speech of our worthy President McKinley. Thank you. (Applause.)

President Gary: You all know the efficient and altogether splendid work that has been done in behalf of the government of the United States in the past and that is now being done in behalf of the United States by General Goethals. (Applause.) I was told this morning that the General had consented to come here to-night upon condition that he would not be asked to sit at the main table and that he would not be asked to speak. He took his seat at one of the other tables, but I finally coaxed him to this table, and having got him very near Mr. Farrell and myself and some of the other gentlemen, we have coaxed him to say something. (Applause.) I did not do that because I love him less, but rather because I love you more. (Applause.) I have the very great honor of presenting Major General George W. Goethals. (Loud and prolonged applause, everybody standing.)

General Goethals: Mr. President and Gentlemen: As I have been sitting here to-night, and as I need assistance and co-operation in my work, I concluded that I would tell you my troubles and ask your help. On the principle of selective draft, I have been called again into the govern-

ment service. Why I was selected, not being a shipbuilder, I don't know. I was confronted with the proposition that it was the intention to turn out one thousand 3,000-ton wooden ships in eighteen months. They were going to the wooden ship program because it was not possible to get steel, and because the wooden ships could be constructed in less time than steel, even if the steel were procurable. I found that contracts for wooden ships had been promised in all directions, but when I looked into the question of the plans and specifications of the ships that they contemplated building, there were none. When you consider that the birds are now nesting in the trees that are going into those ships, and that in order to escape or stand some chance of escape from the torpedo fired by the submarine, those ships must have a speed of not less than ten and a half knots, with a possible speeding up to eleven knots, the proposition seems simply hopeless. I have never hesitated to express my opinion when opportunity offered. Before doing so, however, I came over to see my friend, Mr. Farrell, told him the situation and asked him if it would not be possible to turn to steel as well as wood. He assured me that it would be. Acting on that, I announced the impossibility of the program to which I was assigned, and asked for permission to turn to steel as well as wood. I finally succeeded in getting it.

Fifty million dollars had been appropriated for the use of the Shipping Board to be obtained by the sale of Panama Canal bonds. No effort had then been made to sell those bonds. Money is necessary in building ships as in anything else in life. So I began a campaign for money, and as I have frequently announced that I regard all boards as long, narrow and wooden (laughter and applause), and being a firm believer in absolute authority in all undertakings, I wanted money and authority.

My money and authority are now being discussed by the House Committee on Appropriations, and they promise that probably in ten days or two weeks, I will get the money.

After my first conference with Mr. Farrell, I had a second one, in which he promised, if I went to steel ships, to get back of me and see that my program was carried out. With that

assurance I have been before the committees of the two Houses of Congress and told them that I would endeavor to turn out in eighteen months' time three million tons of shipping (applause), and having in mind that the shipping that we now build should ultimately go into our merchant marine if they escape the submarine, the ships should be, as far as possible, of steel construction. And right here is where I want this Institute to get back of Mr. Farrell and assist me in making good that promise. (Applause). The shipyards are full. I have asked for legislation which will enable us to speed up the ships which are now being constructed and prevent the shipyards from laying down any additional tonnage except for us. Other means must be found besides the shipyards if we are going to make this program, and I want to enlist the co-operation and assistance of the structural steel people and go as far as possible to the fabricated ship in addition to the built ship. I want to go even further than that. I have got to have the co-operation of the manufacturers of machinery, the manufacturers of chains and anchors, of wire cables, in fact, everything that goes to make the completed ship, and if Lloyd George's statement is true that ships are going to win this war, then everybody who helps in the production of completed ships is helping to terminate the war. (Loud and prolonged applause.)

President Gary: Gentlemen, you know that I gave out a statement two or three days ago to the effect that the United States Steel Corporation with all its companies would do everything within its power to assist the government. I want every steel man in this room who feels the same way to stand for a moment. (The entire assembly rose.) General, there is the answer to your inquiry. (Applause.)

I will next call upon Mr. Harry G. Stoddard, Vice-President of Wyman-Gordon Company, Worcester, Mass.

Mr. Stoddard: Mr. Chairman and Gentlemen of the Institute: After the Judge's attempt this morning at finding volunteer speakers, it seems to me that he has resorted to selective conscription. (Laughter.) That accounts for my standing on my feet, and but for the fact that he blames

the committee for the program, it would be the first time that I ever had occasion to doubt his judgment. (Applause.)

I have been wondering why I was asked to be on the program, and I think I am really presented as an exhibit in the presence of this organization, of which I am proud to be a member, but whose membership is made up largely of steel manufacturers. I think, perhaps, the Committee thought they ought to have one lone consumer. We were a very popular class of people a few years ago. (Laughter.) You came to see us, you sent us cigars, you invited us to dinners, you broached to us the wonderful story of the quality of your product. To-day we are left alone and desolate. We hunt you up. We find the doors closed and the sign on them: "Out until 1918." However, having been in the steel business once myself, and now a fabricator of steel which I have to buy, I want to say of this principle of co-operation, these plans which have been proposed by many speakers to-night, the consumer who knows you does not fear and heartily approves of it. We are willing to put our interests in your hands, based on the way you have treated us during the past.

The duty of an informal speaker like myself at the close of such a wonderful day is very difficult. Certainly nothing new can be added to what has been said. Such a speaker should confine himself very briefly to mentioning some of the things which have impressed him, and thus help us to go away with some of these wonderful thoughts deep and clear in our minds.

As a preface to the few words that I have to say, I am going to ask the Judge's pardon for making a personal allusion. I remember very well the first time I met Judge Gary. It was about the time the Steel Corporation had been formed or shortly after. I was connected in a humble way with one of the constituent companies and had some business with some official of the corporation which carried me over the noon hour, and I was asked to stay at one of the luncheons at No. 71 Broadway. As a green boy from the country, I sat back in the corner. After the luncheon a general conversation was taken up, and finally the Judge said,

"Gentlemen, how many commandments are there?" Some one very quickly said ten. The Judge remained silent, and some one else said eleven. The Judge said, "Right. Which shows you should not answer a question unless you can go further. What is the eleventh commandment?" And the gentleman said, "A new commandment I give unto you, that ye love one another." That was the text of co-operation and the recognition of the duties of service and responsibility which the Judge then set forth, when it was not popular and when many said that it sounded good but was not practicable.

It was no new ideal, because the quotation was two thousand years old, but the Judge, at the head of his great institution and with the great influence which he possessed, has shown that it was practical. And during all the years since then, you and I have watched him and those associated with him and those who hold his opinions, and we know that through good times and bad times, through times of popularity and through times of criticism and distrust, he has never wavered from those principles. We are learning that the best salesman is not the man who gets the highest price, that the best buyer is not the man who pays the least, that the most successful man is not he who makes the most money, but that the business concern and the individual is most successful and most worthy of honor who performs the greatest service. (Applause.)

I have been impressed, as I have sat through the meetings to-day, by the wonderful development during these last fifteen years in the recognition of this principle; and I believe that in the course of human events conditions are brought to pass when we most need them. Locked up in the bosom of nature were all these things which we have now grasped and turned to do our bidding. And now in this present great crisis it seems as though these years of preparation in which we have been led by our chairman have brought us to the time of all times when it was possible to exercise the power for good that is represented by that principle and this great institution. (Applause.) It seems to me that the evidence during the last sixty days of the rallying of business to the call of our country under conditions somewhat dis-

couraging, with many things going on that we are restive about and cannot understand, we are forgetting all of those things; and the spectacle is before the world of the business in a country that has not had proper encouragement or proper recognition of its principles, offering itself unstintingly, asking not for the future but devoting itself to the present.

As I have talked with many to-day, socially, in and out of these meetings, the sentiment has been remarkable. There has been no undue pessimism; there has been no light-hearted extreme optimism. A recognition of the crisis and a stern determination to do our bit, and not one word, in private or public, have I heard that has to do with selfish profit. The speeches you have heard to-day would not have been possible fifteen years ago, any more than this institution would have been possible fifteen years ago, with the same spirit that is animating it. I think it is well that we should once in a while stop and see the progress that we have made, even as we realize the problems that are before us. If you and I did not believe that out of this great war something good was coming, we would all feel hopeless. One thing I prophesy will come. I think the desire of our President—really the work of his life—will be realized when, after the war, and victory has come, as it will (Applause), that all shall count the causes that contributed to the war. And the reward of business will be the recognition fully, by public sentiment and the government, of the great part played by business, and business will be accorded the dignity and the place that belongs to it in time of peace which it has had in time of war. (Applause.)

PRESIDENT GARY: Mr. R. B. Carnahan, Jr., Vice-President, American Rolling Mill Company.

MR. CARNAHAN: Mr. President, Ladies and Gentlemen: We have all listened with great interest to Mr. Topping's discussion of the subject "Co-operation and the Mobilization of Public Sentiment," and to the speakers following him, and I am sure that we are all in accord with the deductions and conclusions. Mr. Topping has made several specific pro-

posals. I will not attempt to add to these, but rather to emphasize why they are practical at the present time.

Those strong and hardy men, the early settlers of America, came to our shores for the purpose of securing civil and religious liberty, and the government that eventuated is probably the most individualistic in the world to-day. In those days individual vigor and courage were of great importance. Every man had to fend for himself and his family, fighting the battles with wild nature. The old world from which these men came had been suffering from too much government and too little personal liberty to the people, and the government that was formed in this country was intended to give the greatest liberty for individual initiative.

These conditions, however, have been changing, and for several decades we have seen our country emerging from the condition of a frontier nation to one of the great industrial and commercial powers. Small business has been giving way to large business. We have grown more efficient as we have grown more dependent on one another. Employers and employees are co-operating to-day as never before. Co-operation is the spirit of the times. Standardization in all lines of industry is gaining ground rapidly.

The Allies have been learning co-operation from Germany, but have been applying democratic ideals in achieving the result.

The European war, especially in the earlier phases, has illustrated the great advantages of co-operation as nothing else has ever done. The co-ordination of Germany's industries and every phase of her national life have made it possible for her to accomplish what she could not otherwise have brought to pass. It is true that Germany's government is autocratic, but nevertheless co-operation and co-ordination of her resources and industries have been the basis of her success thus far.

At the beginning of the war none of the Allies was prepared in anything like the manner or as thoroughly as was Germany. Their later successes and the dearly bought preparedness that they have finally achieved are due to the

fact that they have brought about co-operation in its many phases and co-ordinated the industries and resources for the commonweal. England to-day is in many respects a very different England from what she was three years ago. The country has been born again. Prior to the war France herself admitted that she was decadent, but to-day we have a new France, a wonderful people working as a unit for the success of their country.

The irresistible tendency of modern thought is co-operation and to a large extent the subordination of the individual right, where such subordination gives the greatest liberty and does the greatest good to the majority. True liberty is brought about not by license but by controlling the individual in such a way that he will not encroach upon the rights of those around him, and also by protecting his rights and securing to him individual justice.

As a result of the injustices of ancient laws and customs not in accord with modern conditions, we have seen the interests of capital and labor in conflict. These differences should be adjusted by wise legislation and by co-operation between the conflicting interests and government. Mr. Topping has made some very apt suggestions along this line. He has further stated that the passage of the compulsory service or the selective draft law is the beginning of a new era for this country. It is impossible for us at present to estimate the great good that will come of it and the patriotism that will be instilled in our breasts as a result thereof.

America to-day is being transformed. In order to do our part in the war, to which we are now definitely committed, we must make our individual interests subservient to our country's needs. England, France, Belgium and Italy have adopted co-operation and co-ordination to serve the ends of democracy. If the American republic is to endure, it must do likewise. (Applause.)

President Gary: I am hoping to have the great pleasure of presenting to you Mr. Marcel Knecht, Delegate of the French National Committee, Nancy, Lorraine. Is Mr. Knecht here?

Mr. Knecht: Mr. Chairman, Ladies and Gentlemen: The French High Commissioner, Mr. André Tardieu, recently arrived in Washington, where he comes to organize the co-operation of the work with the American government and who was invited here this evening, greatly regrets his inability to come, and I take this opportunity of reading to you the special message which he asked me to deliver to your Board and to this Institute:

> Mr. Chairman, I regret deeply not to be able to attend the banquet of the Iron and Steel Institute of the United States, to which you had the kindness of inviting me, and I beg you to accept my excuses. I should have been happy to meet to-night the members of the powerful association over which you preside and which plays in the actual war a part of capital importance for the complete victory of the United States, of France and of their allies. I hope in a near future to have the honor and pleasure of meeting all of you, and I beg you to transmit to your colleagues my heartiest greetings.

Gentlemen, in the steel train which took the French Mission, Mr. Viviani and Marshal Joffre and the other members of the Mission through the United States—and because of that steel train the accident was only a small accident—the members of the Mission had the joy of admiring through the night the wonderful fires at three o'clock in the morning of that great city of Pittsburgh. They saw the fires of Harrisburg, and they saw and they heard, too, at six o'clock in the morning, all the whistles of the engines of Philadelphia to awaken them. They saw with what ease the soil of this country produced the iron, and they imagined the wonderful production of iron, where the strength of the United States lies. But they also had a deep sorrow when remembering that in their native land there was also a spot rich in this iron, which all of you love and respect. They thought of this beautiful and rich country of Lorraine, of Lorraine rich in iron and rich in soldiers, of Lorraine the richest spot in iron in Europe, of Lorraine invaded since the beginning of this conflict, where our best factories, where our best iron mines were, where was the activity of the French nation. They thought of all that, and they remembered that just in August, 1914, there was to be in Nancy a conclave of the

congress of the Iron and Steel Institute of Great Britain. Our friends of Great Britain were to visit the famous mines of Lorraine, but the war came. We were invaded. These beautiful districts, where the work was so intense that they were obliged to use the help of one hundred thousand Italians, all workmen, these districts were invaded, plundered, spoiled; all the iron has been taken out and used to make shells and guns against ourselves.

Then let me tell you that this iron question which interests you so much can be considered, more than anything else, as one of the principal aims which pushed not only the Kaiser, not only the German autocracy, but more than that, the German iron mine owners, to declare war on France. There was near to them rich places and interesting spots of iron; this iron was only good for Germany. This iron was necessary for the German industry. We had been these last years exchanging our iron—which was, too, important for us—against the German coal. But we had recently found in Lorraine coal mines. We were thinking of exporting iron to England and receiving from England coal. We were using these new coke ovens of Belgium and we were thinking in that way to keep for ourselves our iron. Germany, which preferred to declare war because of the imperialistic tendencies of her government and of her leading industrial men, saw that these Lorraine iron mines were good, and that is one of the strongest reasons for this war. I think that this will interest you, you men of American iron.

Now, another thing I want to tell you: France, though lacking iron, though lacking coal, though lacking the best industries where the guns and shells were to be made, could make in the south, in the west, in some parts of the east which were maintained by the bravery of our troops, as the Bassee of Nancy—we could make these big guns, this big artillery similar to the German artillery, which is now the best help of our soldiers on the front of the Somme and on the front of Verdun. (Applause.) We could send during the two years shells and guns to our allies, to Italy and to Serbia, and to Russia, and to all those who needed shells and guns. And we must not forget that if we could do this mar-

velous piece of work, it is because we had your help. We had the help of your iron and of your steel. We will never forget that the steel of the United States has been in the fight for justice and for liberty since the beginning of the war. (Applause.) It is through the iron of Lake Superior, through the iron of that extraordinary city of Duluth, which I regret the French Mission could not visit to see how America is able to do wonders in industrial branches. It is true that through the iron of Alabama, through the iron of the United States, this fight has been going on and the battle of the Marne and the battle of Verdun have been fought to the end successfully. (Applause.) We will never forget it, gentlemen. And it is for me a great honor to be able on behalf of my country and on behalf of Mr. André Tardieu, the High French Commissioner, to tell you again how thankful we are. (Applause.)

Now, gentlemen, I insist on this again. You gave steel to us, but you gave more—you gave your heart. You gave the heart of these fine American women, your wives and your daughters, who answered our call at the first moment, who came to give their services as nurses in our hospitals. And how hard they worked, so generously, to bring help to our civilians, to our wounded, and to our nation. You gave your heart, and when the German troops were marching down from poor invaded Belgium, when they were marching through Amiens, through the rich plains of France, and through Champagne, these troops thought that German steel, that Essen steel, would crush the France of the peasants and of the artists. But you were there. You stood up. The American steel came in front of the German steel and the American steel was stronger. (Applause.)

And for that reason these places of the Lake Superior region, where—and we can say it with pride, we Frenchmen—the French civilization was so strong some centuries ago, where our missionaries were strong and powerful, we are proud to think that from that part of the United States, the spot so French formerly, the help has come strongly to France. Mr. Bergstrum, our great philosopher who just left the United States, used to say here—and though he is a

philosopher, he is a great man and a great peaceful spirit—he used to say, "Germany wanted to use the gun against everybody in the world; then we must use the gun ourselves. This is the only way to finish this conflict between autocracy and democracy, between injustice and right," and to finish we can say that through and with your steel we have now a pure blood of brotherhood. Americans, Frenchmen, British, Italians—all are allies. We are only one blood. We are only one pure piece of steel, loyal as steel, and we are loyal to each other as steel. And we must also bring together, and we have done it already, our experience, our strength, our courage, and the bodies of our soldiers, and this conflict will certainly have one result, if no other, and that is, that we shall know each other better. We have needed sufferings to do this, to realize that for many years the United States and France ought to have been still more strongly united, and that if we had been ourselves united, had been organized as we are organized now, this conflict would never have taken place.

But we hope that soon, with your co-operation, with the help of these great Americans we have here this evening, we shall be able to clear the soil of France, to clear the soil of humanity from the autocracy which is now treading on all liberties and on the souvenirs, the most sacred of the world. We need your help. We have your help, and for this reason let me thank you heartily, and let me thank the American Iron and Steel Institute for having given me this opportunity of telling you what we think about the United States. (Loud and prolonged applause, everybody rising.)

The Chairman: Gentlemen, it is very late. I am sorry we shall not be able to remain longer to hear from some other gentlemen we had hoped to call upon. This has been the greatest day in the experience of the American Iron and Steel Institute. We have become strong and are growing stronger, and as we do better and are better, we will be still greater. In honor of our French friends, let us close with the Marseillaise.

(The Marseillaise is played and sung, all standing.)

President Gary: Good night.

OCTOBER MEETING

CINCINNATI - - OHIO

OCTOBER 26 AND 27, 1917

AMERICAN IRON AND STEEL INSTITUTE

THIRTEENTH GENERAL MEETING

Cincinnati, Ohio, October 26 and 27, 1917

The Thirteenth General Meeting of the American Iron and Steel Institute was held in Cincinnati, Ohio, on Friday and Saturday, October 26 and 27, 1917. The day sessions on the 26th, for the reading and discussion of papers, were held at the Hotel Sinton. During the noon recess, the members were the guests of the Institute at luncheon and the Board of Directors held its usual meeting.

The semi-annual dinner was held on the evening of the 26th in the ball room of the Hotel Sinton, which was handsomely decorated for the occasion. Appropriately, the wall decorations were American flags grouped in different ways. Judge Gary's address in the morning struck the keynote of patriotism, and this note reverberated through the day and the evening, as will be seen by the report that follows.

About twenty-five ladies, wives and daughters of members, had accompanied them to Cincinnati. On Friday they were entertained by the Ladies' Committee of Cincinnati, wives of the members of the local committee. They were taken in automobiles to the Cincinnati Country Club, where they were the guests of the Cincinnati Ladies' Committee at luncheon. In the afternoon they were taken to the Cincinnati Art Museum and the Rookwood Pottery. At this famous pottery each lady was given as a souvenir a handsome art product of the pottery. In the evening the visiting ladies were the guests of the Cincinnati Ladies' Committee at dinner in the Green Room of the Hotel Sinton, after which they adjourned to the ball room to hear the post-prandial addresses.

On Saturday the members of the Institute and the ladies with them were the guests of the Local Committee. Two programs had been arranged. One of these made a two-hour tour of Cincinnati and its suburbs, with a luncheon at noon at the Cincinnati Country Club. The other tour was through the Kentucky highlands for a visit to Fort Thomas, with luncheon at the Fort Mitchell Country Club. In the afternoon Hon. Charles P. Taft kindly opened his famous art gallery to the members of the Institute and the ladies with them. Altogether, Cincinnati maintained its high reputation for hospitality, and the members left for their homes with pleasant memories of their visit.

FORENOON SESSION, 10.00 A. M.

Address by the President............................ELBERT H. GARY
Chairman, United States Steel Corporation, New York.

Cincinnati and Its Industries........................DANIEL B. MEACHAM
Partner, Rogers Brown & Company, Cincinnati, Ohio.

Recent Installations of Large Electric Motors in Rolling Mills.
SAMUEL S. WALES
Electrical Engineer, Carnegie Steel Company, Pittsburgh, Pa.

Discussion...WILFRED SYKES
Electrical Engineer, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

Discussion...K. A. PAULEY
Power & Mining Engineering Dept., General Electric Company, Schenectady, N. Y.

Iron and Steel Scrap.............................W. VERNON PHILLIPS
Perry, Buxton-Doane Company, Philadelphia, Pa.

AFTERNOON SESSION, 2.00 P. M.

Fifty Years of Iron and Steel....................JOSEPH G. BUTLER, JR.
Youngstown, Ohio.

Malleable Iron and Its Uses............................HENRY A. POPE
President, National Malleable Castings Company, Cleveland, Ohio.

Discussion.....................................ENRIQUE TOUCEDA
Professor of Metallurgy, Rensselaer Polytechnic Institute, Albany, N. Y.

Discussion...F. J. LANAHAN
President, Fort Pitt Malleable Iron Company, East St. Louis, Ill.

Discussion...F. E. NULSEN
President, Missouri Malleable Iron Company, East St. Louis, Ill.

Discussion...J. C. HASWELL
President, The Dayton Malleable Iron Company, Dayton, Ohio.

The Export Trade as Affected by the War.............EUGENE P. THOMAS
President, United States Steel Products Company, New York.

EVENING SESSION, 7.00 P. M.

SEMI-ANNUAL DINNER

Impromptu Remarks in Response to the Call of the President.

ADDRESS OF THE PRESIDENT

Elbert H. Gary

Chairman United States Steel Corporation, New York

Gentlemen of the American Iron and Steel Institute: In your behalf, and in mine, I beg to extend thanks to the citizens of this great metropolis for their generous hospitality, for their kind reception, and for the confidence they have expressed in us and in our work, as shown by their attitude and their efforts; to extend congratulations to the citizens of this splendid city for the progress they have made and are making, and for the position they have reached amongst the great cities of this country. I beg to express to the gentlemen who are to address the convention during the day and evening, our gratitude for their work, their painstaking effort to please and to advise and instruct us, concerning the topics which have been assigned to them, and to express the admiration of all others here for the talent which is shown by the papers already submitted to a few. I beg to convey to the committee in charge of the program our thanks for their efforts in providing such a splendid literary entertainment, evidenced by the papers which will be presented and read, and to all of you present, I voice the feeling of gratification that the Directors of the Institute have, because of your presence here and on other occasions, and for the efforts you are making from time to time, to carry on the work of the Institute and to place and keep it in the high position which I believe it occupies in this country.

Work of Institute Committees

At the last annual meeting of the Institute reference was made to the appointment and the activities of a general committee and sub-committees of the iron and steel industry. These committees were appointed and were serving as auxiliary to the Advisory Committee of the Council of National Defense. However, in view of special

legislation of a recent date concerning transactions of a business nature between the Government and private interests, it was, from an abundance of caution, decided to abrogate the appointment of these committees; and immediately thereafter your president, after consultation with his associate directors of the Institute, named a general committee and also sub-committees representing the different special lines of the industry. This general committee and also the sub-committees, directly or through the general committee, have been reporting their recommendations from time to time to the War Industries Board at Washington consisting of Messrs. Frank A. Scott (Chairman); Robert S. Lovett, Robert S. Brookings, Bernard M. Baruch, Hugh Frayne, Admiral Frank F. Fletcher and Col. Palmer E. Pierce. This Board in turn has reported its recommendations to the President for decision. From the published accounts or otherwise you are familiar with the results which have been reached.

Many of you were disappointed when the prices of the commodities in which you are particularly interested were announced. You had expected larger figures. You had been receiving from your customers, in the ordinary course of trade, much more favorable results. Your profits will be less than you have believed you are entitled to. Your costs of production and construction are increasing by leaps and bounds. Many manufacturers have struggled for existence in periods when business conditions were bad, trusting to the future for improvement, and they have argued that if the law of supply and demand should govern under such circumstances it should control at this time and all times. However, all these things have been considered by the iron and steel committees, and by the representatives of the Government as well. It is only stating facts to say that the former have endeavored to represent the manufacturers conscientiously, intelligently and forcefully and that the members of the War Industries Board have at all the hearings given patient attention, thorough investigation and careful consideration to every claim presented, with the sole purpose of doing justice both to the Government and to the individual.

The members of our committees insisted upon higher

prices than the ones finally agreed upon, but they consented to those which were fixed because they were influenced by motives of patriotism and also because they became convinced that, in the main, the prices came within the original proclamation on the subject by the President which, from the standpoint of the Chief Executive of the Nation, was reasonable and just.

If, as between the different products, semi-finished and finished, disparities in prices should be discovered, then, so far as practicable, they should be removed. You may rest assured that the intention of every one connected with the ascertainment of facts and the determination of prices is above reproach.

It may be suggested that some of the producers will realize larger profits per unit than others owing to greater diversity of commodities, favorable location, better organization, larger production or other circumstances which tend to lower costs, but it should be borne in mind that the progressive rates of governmental excess profits tax, depending upon the relative earnings of the different producers, will largely offset the differences in net result. It is estimated some of the manufacturers will be obliged to pay to the Government as high as fifty per cent. excess profits tax.

The Committees representing the steel industry have labored hard and faithfully in the performance of their duties. They have carefully considered every suggestion which has been made, from time to time, by those engaged in the industry relative to their rights, interests and claims. The facts concerning capacity, advantages or disadvantages, costs and profits of each, have been gathered, so far as practicable, with the purpose of determining the relative positions, rights and obligations of all; and these have been honestly presented to the War Industries Board, and, before their appointment, to the Secretaries of War and Navy, and to various boards created by the President or by the Council of National Defense. The general committee has met frequently in New York and Washington, giving these matters attention in preference to all others and regardless of per-

sonal comfort and often without adequate rest. Omitting the chairman, who frequently has been relieved of work and favored in many ways, I state with emphasis for the benefit of those who are not fully informed that the other members of the general committee, as well as the members of the sub-committees, are entitled to the gratitude of all others who have been interested in this work. In the collection and distribution of figures affecting the different branches of inquiry the American Iron & Steel Institute has rendered valuable assistance and is entitled to and has received much praise from the members of our committees and also from the Government's representatives.

Good Work of Government Agencies in Washington

And the members of our committees, better than those who have not had similar experience during the last year, recognize with appreciation the comprehensive and efficient work that has been and is being done by the large number of governmental agencies in Washington. There has been created a vast business organization, with scores of departments, and a larger number of sub-departments which are carrying on the greatest of all great business undertakings; and, notwithstanding some unfavorable criticisms which have been made, many, if not most, of which are wholly unjustified, it should, in truth, be said this colossal combination of diversified, rammified and intricate business activities, involving more or less political, social, commercial, financial and industrial life, is becoming, almost has become, a smooth running machine. That mistakes have been made, that steps have had to be retraced, that sometimes action has been too hasty and other times too deliberate, that red tape rules, created by legislation or otherwise, occasionally have interfered with the best results, may be assumed; but with patience, skill, persistence, vigor and success, the great varieties of business enterprise, as time has elapsed, have been better and better co-ordinated and the whole structure has been developed nearer and nearer to the point of perfection. I do not hesitate to say that, so far as there has been opportunity to observe, the

results in Washington have excited my surprise and admiration.

And the most wonderful feature of this work is not its magnitude, nor even its results, which are becoming exposed to the view of the general public, but rather it is found in the fact that the work is largely under the management of very able business men and women who are volunteers and are devoting their time and skill and energy without compensation, or hope or desire for reward of any kind, except in the consciousness of duty performed. There are large numbers who have disregarded personal interests, their personal comfort, and some, even their personal health. These men and women are outclassed, in disposition to sacrifice and to serve, only by the members of the Army and Navy who bare their breasts to the destructive forces of warfare.

The War Industries Board

Of this vast civil army of effectives, the staff that of late the representatives of the Institute and its members have appeared before is the War Industries Board, already referred to. The members of this Board have other matters of interest which need attention. Some of them had hoped to retire from active business and to enjoy a well earned rest; some of them are in the very prime of life and were actively connected with important business enterprises, with every prospect of a long and successful career. All are possessed of vigor of mind and body. Not one of them personally considers himself or any other individual or any interest that may appear before the Board. They have no one in mind to favor or to punish. They are considerate and respectful, but they are obdurate when a claim is presented which seems to them to be unfair or unreasonable. They serve their country faithfully by their effort to be practical, discriminating, reasonable, just. And the assistants to this Board, representing a diversity of talent and experience, are of great benefit to the Board in the ascertainment of facts and the application of principles and comparisons. Some of them you know personally, and the

high qualifications of all of them most of you are acquainted with.

Reference has been made to the general business organization of the Government and those connected with it for the purpose of suggesting to each of us present to-day our duty in this time of trouble and sadness; and to the character, disposition and qualifications of the members of the War Industries Board for the purpose of making prominent the inference that the steel committee could not, if it desired, secure from this Board at any time a determination or recommendation to the President which was unreasonable; and that every one would be ashamed before such a body of men to urge any claim he did not believe to be sound and proper.

For the purpose of making deductions further on, it is deemed appropriate to again make reference to the war in Europe. This has become an old subject, but, as the years roll by, has, to a greater rather than a lesser extent, absorbed our attention.

Prussian Germany's Aggressive Ambition

Whatever opinions we heretofore may have entertained concerning the motives, intentions and efforts of the Prussian Germans the evidence which has been accumulated from time to time through reliable sources has forced the conclusion that for a long period preceding August 1, 1914, there was perfected a systematized plan for precipitating or of provoking an international military conflict which it was expected would result in victory and final geographical and political domination by Germany of the whole of continental Europe and Great Britain and later of Canada and the United States and finally to include such parts of South America, Africa and Asia as might be considered desirable from the standpoint of a powerful, aggressive, ruthless and tyrannical monarchy. In short, Prussian Germany was obsessed with the ambition to rule the world.

The history of Napoleon, of Caesar, of Alexander and other great military leaders had been studied with the view of adopting and adapting the most powerful traits of each.

A military organization superior to any that had ever before been created had been built up. There had been formulated a system which included the most effective arms and ammunition and other military supplies, transportation facilities, the creation of an army with training, and officers equal to the best ever seen, the creation of a spy system more extensive, more dastardly and more powerful than any previously attempted, the perfection of a bureau of information, publication and secret distribution which even to this date is provoking internal strife and national hostility in many other countries.

Besides, immense quantities of food stuffs, war material, equipment of all kinds and everything believed to be essential to carrying on an aggressive and extended war had been gathered in warehouses for use when war should begin. The mere hint at these conditions is sufficient to recall to your minds the innumerable ways in which a comparatively few men, who were parties to the conspiracy, determined upon for the purpose of rapidly forcing the passage into Belgium, France, England, the Balkans and in fact every other coveted country which would not voluntarily become a party to the plot. Almost by a miracle the aggressors were prevented from entering the City of Paris, of possessing substantially all the raw products necessary for the manufacture of iron and steel located in France and of so disabling that nation that she would have been of little value in the conflict; and after that, of proceeding, sooner or later, to Great Britain.

Germany's Two Grave Mistakes

It usually happens that the worst criminals make some fatal mistake in the execution of malignant plans, however carefully studied. Germany made two grave mistakes at the outset. First, she believed she could enter Belgium and France without any interruption, but she was mistaken by a few most important days. And she was mistaken in assuming that she could violate her solemn treaty and trespass upon the territory of Belgium on the ground that treaties were mere scraps of paper, without offending the

sense of honor and decency of the entire neutral world. From the time Germany deliberately and maliciously broke her agreement to observe the neutrality of Belgium her doom was sealed, although it may and likely will be some time before full punishment is administered.

All who are here will be able to supply many of the omitted important features of the indictment which the world will hereafter record against Prussian Germany, only a skeleton of which I have presented.

The war already has been long and terrible, and the end is not yet in sight, although, of course, there is always a possibility of a sudden, if unexpected, break and collapse. It is certain that, except on the basis of a conclusion satisfactory to the United States and her allies in this war, there is no prospect of an early termination of hostilities. It is clear we must prepare ourselves for a long and uninterrupted continuance of the war. The foe is strong and desperate. He must be overcome by physical strength and endurance, unless the masses of the people of Germany shall become acquainted with the facts and forcibly insist upon having a voice in determining the policy of the nation.

The Great Strength of the Allies

But the Allies are possessed of the necessary elements of strength to win. They have at least three men against two, and they are or soon will be more fit than the soldiers of the enemy, man for man. The next thing in importance is food. In this respect the resources of the allied countries for each person is far superior to those of the enemy. The next in rank of necessity is steel. Without this in abundance neither side could maintain an adequate offense or defense on any battlefield provided the opposing forces were well equipped. The Allies have a productive capacity of steel three or four times as large as the Central Powers. Of course, with steel and what is produced from it, goes hand in hand the necessary explosives.

And underlying the utilization of all the military resources of the Allies is the question of money and credit. The country which is greatest in finances, all other things

being equal, will eventually succeed. The financial strength of the allied nations is many times greater than those of Germany and her allies.

It was suggested in the President's address at the annual meeting of the Institute in May that if the Allies had the best and most effective types of aircraft, outnumbering those of the other side five or ten to one, they would have a decided advantage and would thereby materially shorten the conflict. But it is pertinent to say that our side to the conflict should secure and maintain a superiority in each division of the war program. We must have soldiers, better equipped and better supplied, more and better guns of the best character and quality, greater quantities of the most effective ammunition, a larger number of the finest types of aircraft, the fastest and most destructive vessels of offense and defense on the seas, the best and quickest transportation facilities by sea and by land and every other facility of practical utility, of sufficient strength and power to overcome all resistance.

The Allies are in the financial condition to provide themselves with all these essentials, if they have the brains, the energy, the courage and the persistence. No intelligent person who is partial to the cause of the Allies or who is entirely impartial in considering the merits of both sides will admit that there is any doubt the peoples of the allied countries are possessed of mental capacity fully equal to the peoples of any other country.

The Patriotic Duty of American Steel Producers

If the members of the Iron and Steel Institute agree with what has been said thus far, as from a long and intimate acquaintanceship I believe they do, then it is easy to determine and to follow the lines of duty. We occupy a position of the highest importance in the present war. Our country and its Allies in the international conflict are in need of every pound of steel that can be produced in this country and which can be used for war purposes. To insure this supply, every furnace and mill having relation to the subject must, without interruption, produce to the fullest capacity and subject to the control of the Government

through its lawfully constituted agencies. No excuse for neglect, delay or interruption will or can be accepted by the Government. The administration desires and intends to pay fair and reasonable compensation, sufficient to maintain existing wage rates, salaries of officials and extensions necessary for war purposes. Up to the present time we have no reason to complain of the attitude and action of the Government, although we may have been disappointed in some respects. It is up to us to prove our continued loyalty to the Government; but more than that, our loyalty to ourselves in the performance of duty. Even though there should be dissatisfaction concerning prices or the details relating to production or distribution of tonnage, still production and deliveries must continue without interruption or diminution, leaving any question at issue to be settled at a later date. So long as the attitude of those in control of governmental affairs towards producers remains as it is at present, it must be our effort, as it will be our pleasure, to do our part unselfishly, wholeheartedly and assiduously.

If our country is defeated in the pending military conflict your property and business and mine will be of little value. We will have retraced our national steps a century and a half. The wealth of the country would be seized and retained as prize money by other nations. We have been forced into the war and we are compelled to fight in defense of our persons, our property and our sacred honor. There is no escape. We are in the war to the end, however costly and bitter. No man, no country was ever engaged in a more righteous cause or a more compulsory defense. If we do not do everything practicable to uphold the hands of the President and to add to the success of the defense against the foreign aggressor we are less than men; we are weaklings; we are poltroons. I believed for a long time we could and would be kept out of the war, but it was impossible. The President delayed as long as he consistently could. We must now fight with every weapon within our reach. We must liberally subscribe to the Liberty Loans. We must cheerfully pay our taxes, and, of still greater importance, we must furnish steel in larger and still larger quantities.

If we succeed in this war, if we do our duty, life will be worth living. Our country will occupy a place in the front rank of worthy nations. Democracy in its truest sense, one that means "a whole people, unified, with one law for rich and poor, equal opportunities for all men," will be firmly established. A basis for preventing future prolonged wars will be secured. Our properties, our businesses will be more valuable than ever. Progress and prosperity will be in evidence on every hand. The war will have been a real, substantial benefit to the entire world. The moral strength and power of this country and other similar countries will be greater than ever before. If we believe the Allies can and will win the war, then we may be pronounced optimists for the long future.

On the battlefields of Europe men are dying by thousands and tens of thousands. Our sons or brothers or other relatives will soon be active participants. I fear the rolls of the dead or injured may be brought across the ocean within a few months, although I hope for the contrary. These men who have cheerfully offered their persons as a sacrifice to a noble cause are appealing to us by thought if not by word for such assistance as we may render. Every dollar we expend, all necessary material we furnish, every sacrifice we make, will assist in protecting the lives and health of the patriots who are abroad in defense of our rights. We must not, we cannot, withhold anything that will be of benefit to those splendid men. (Hearty and long continued applause, entire audience rising.)

President Gary: Informal discussion under the five minute rule. There are many patriotic orators in this room who would like to say something. Here is your opportunity. I am sure everyone will be glad to listen to you, and none more than I. Don't wait to be called upon; many of you would like to say something, and all would like to hear you say something. Colonel Lambert, will you speak?

Colonel John Lambert, Chicago: After hearing what you have just been telling us, there doesn't seem to be much

else to do or say, except that I endorse every word that you have said. The American Iron and Steel Institute and the manufacturers of America will do their full duty. (Applause.)

Mr. Clarence H. Howard, St. Louis: I feel that the message President Gary has brought to us ought to sink deep into our hearts. I think he has put it before us in a way that will make us all soldiers, when we are called by President Wilson for any service that we can render this great nation, —the greatest nation on the face of the earth. It is for us, to bear the torch to help light the way for the balance of the world, and I know of no better work that has been done by our great President, Judge Gary, than in the wonderful message he has sent out, and in the splendid work that he has done from the beginning. I feel that we owe him, and we owe this Institute, and the world owes this Institute a great sense of gratitude for the wonderful manner in which they have handled their part of the problems brought about by this war. (Applause.)

President Gary: Mr. Campbell, there are several looking at you as though they expected you to say something.

Mr. James A. Campbell, Youngstown: I would be glad to say something if I could only express my feelings. I feel there isn't anything much worth while except this war, and that we people must make everybody in our communities feel that way, as far as we can; that the matter of making money is of minor importance; that things not necessary to be done should be left undone; and that we should bend every energy to help win this war. (Applause.)

President Gary: Can we have a word from Canada, Mr. Hobson?

Mr. Robert Hobson, Hamilton: Mr. President and Gentlemen: We used to call the people on this side of the line our "American Cousins". We no longer do that; we have a dearer name for them now, and that is "Brothers". (Applause.) We have admired the splendid energy that you have thrown into the war, so far as you have gone, but you are not really in it yet. When those horrible casualties

come along, then your interest will be intensified a thousand fold. In my little town, I can go along the street and meet man after man who has lost a son or a brother—I can meet many women who have lost their husbands. And then there are those who have been wounded, too. I tell you that fetches it right home to you.

Personally, I am rather optimistic about the war, particularly so after hearing the splendid address of Judge Gary. (Applause.) I believe that the war will be over by next spring, and if you want the reasons, you have them right in Judge Gary's address. He has said that you may not get your casualty lists for some months. I think you will get them sooner than that. I am sure you would all like to know, and I would like to know, how many American soldiers are "over there"; and yet we must all admire the magnificent silence of the press in not announcing the departure of the troops. I was in Halifax in August. Just a week before I got there, six transports left there with American troops. A week later there was another boat load from Montreal with American troops. There are numbers of American officers and American nurses on the streets in Halifax and Montreal, all on their way through. When I left Montreal for the Maritime Provinces, the train I was running on was divided into seven sections; the first section carried white people, and the others were Chinamen. There were practically seven thousand Chinamen going through Montreal to work behind the lines, and I tell you they have taxed the resources of Canada to supply rice to feed them! Gentlemen, I say to you from the bottom of my heart that Canada and Great Britain are truly grateful to you for coming to the assistance of the Allies at this important moment. (Hearty applause.)

President Gary: Gentlemen, I feel this is not time wasted. If anyone thinks it is, I will be glad to hear the suggestion, and I will observe it. I think we ought to hear from Mr. Butler, and Mr. Rogers, and Mr. Farrell, and some of the others before we get through. Where is Mr. Schwab? Out of the room temporarily? Well, when he comes back, we will hear from him. He couldn't keep still!

If anyone has any doubt about how he feels, or whether he wants to talk, look around this room. Someone has planted the inspiration here. Mr. Butler?

MR. JOSEPH G. BUTLER, JR., Youngstown: Mr. President and Gentlemen: I didn't expect to have to talk this morning. I am on the regular program to speak this afternoon, and on other occasions I have been drafted in the evening. But I will say a word that has come to my mind while sitting here.

I read in a newspaper yesterday about Champ Clark criticising the American business men, and the financial interests of this country, for not subscribing to the Liberty Loan. I want to tell you that I came pretty near swearing about it, too. It is an absolute libel on every man in this room. I can tell you a little of what we have done at home. Youngstown was put down for a quota of five million dollars. Two concerns there in which I have the honor to be interested—the Youngstown Sheet and Tube Company, of which Mr. James A. Campbell is president, and The Brier Hill Steel Company, of which Mr. W. A. Thomas is president—these two concerns alone subscribed an amount equal to Youngstown's entire allotment. (Applause.) Youngstown far exceeded her quota. For instance, a campaign was started among the employees of the Youngstown Sheet and Tube Company, and those men alone raised a million dollars, in addition to the five million. (Applause.)

I am not criticising the government; I am criticising one man, and what he said was undoubtedly said for political reasons. It seems a shame that anyone in this country should be permitted to indulge in that sort of treasonable talk, and I enter a protest, which I hope the newspapers will circulate.

PRESIDENT GARY: I don't hold any brief for Mr. Champ Clark, the Speaker of the House of Representatives, but I believe always in doing exact justice, as I see it. I know Mr. Clark very well, and I consider him a patriot. When the newspapers of New York City, as well as in other places, inspired perhaps, by money that comes from a

malicious source, characterize a body of men in New York City, or any other place, as financial derelicts, when they publish misrepresentation after misrepresentation concerning the disposition and the effort of patriotic financiers, is it to be wondered that a man, or a number of men throughout the country, should get a false impression? If Mr. Clark could go to New York, the financial center of the world at the present time, and go into the offices of the big bankers, or into their homes, and could know what work those men are doing, and what work their wives and sons and daughters are doing to support and hold up the hands of the government in this crisis, his opinion would be favorable. I don't think we should pronounce judgment against a man until we are certain he has had full opportunity to know all the facts, and I say conscientiously, and from the bottom of my heart, that I believe Mr. Clark, whose son, I think, is in the army, to be a real patriot.

Don't suppose for a moment, either, that I am criticising Mr. Butler. I subscribe to the sentiment of loyalty which he has expressed. We have no room in this country for disloyalty, or for disloyal men; and speaking to this Institute to-day I am particularly interested to know whether every man will really rise to the occasion so far as his own individual work and opportunities are concerned.

I have said the Government must have steel and more steel. We are entitled to fair prices, and I believe if we do our part, if we live up to the representations which your committees have made, if we keep our mills running, primarily, for the benefit of the Government, and accept the prices tendered, even though we think they are unfair, that we will be treated properly. Certainly, I know, we will be doing our full duty. (Applause.) I am anxious to hear expressions concerning that part of the remarks which I made, not desiring for a moment to abridge the remarks which anyone would like to make, of a patriotic nature. As I said before, I don't think we are wasting time, gentlemen. Our efforts, as well as our minds, are engaged in considering this topic.

Now, I am very sure you would like to hear from Mr.

Farrell. (Applause.) Mr. Farrell has two boys in this war. He is in no frame of mind to speak, but I am going to ask him to say a word. And I tell you, for him, that he is working night and day in trying to do his bit in providing steel to our Government, and he is doing everything else that can possibly be done to assist in carrying this war to a successful issue. Mr. Farrell, will you say a word. (Applause.)

Mr. Jas. A. Farrell, New York: Mr. President and Gentlemen of the American Iron and Steel Institute: America's participation in this war has wrought great changes in all of the industries of the country, particularly the iron and steel industry. This is an economic war. You can send men to the front with guns and munitions, but we must produce the material to support them. It has been said that food will win the war. but the paramount necessities are ships to carry supplies and to maintain the action and activities of the men at the front. The program of the United States shipping board calls for the building of 3,000,000 tons of carrying capacity over the next eighteen months. The program should call for 6,000,000 tons, because in the opinion of men who are competent to speak on the question and who are familiar with the capacities and the requirements, 3,000,000 tons will maintain 700,000 of our men in Europe. I mention this because we are steel manufacturers, and because of the fact that the requirements for ship-building material alone have taxed the capacity of every plant in this country, whether large or small.

This is a time when cherished customs and time-honored privileges must of necessity go by the board. The only thing that we can possibly think of at the present time is the war and the necessity of winning the war. It is the biggest thing that we must consider and the thing that must be accomplished next, as our honored President has said here to-day. If we lose, then we won't be thinking very much as to whether we are going to get one price or another for our product. (Applause.) So that, it behooves us all to give our time and our attention to co-operation, because, after all, co-operation is what is necessary in all of the industries, and particularly in our iron and steel indus-

try. We must give our undivided attention in all of our industries to help one another and to help the Government in bringing this war to a successful conclusion.

I would like to feel that the war will be over next spring, but my own opinion is that we are in for a long drawn-out struggle, in which we will eventually succeed, but it depends upon this country very largely, and upon the efforts of the men assembled in this room to furnish the steel that is necessary to do it. (Applause.)

President Gary: I am going to call upon a gentleman who always tries to avoid making a speech, Mr. Rogers.

Mr. William A. Rogers, Buffalo: I think I voice the spirit of every one present when I say that we are glad there can go out from this room a document which will be so widely read as Judge Gary's address, that presents so forcibly and so greatly what the steel and iron men have been doing, and what is their spirit. I am glad, also, to feel that I have the right to represent another feeling here because as has been said of Mr. Farrell, my only two sons are in it, one to-day in Pershing's Army in France, and the other in the officers' training camp at Fort Niagara. (Applause.) So that, I would like to say that the steel men are sending their sons freely and extensively, as far as they have them old enough, to battle in the front lines across the seas. And, if you ask a pledge of what we will do, I think I can also say for this body of men, Mr. President, that they will do everything in their power to help the Government or to help any part or department of it, to win this war. (Applause.) If there are any who will not—and I can hardly think there will be any such—they will be recognized, and they will be left in such a position that democracy will be unpleasant for them. (Applause.)

President Gary: Mr. Schwab has to speak everywhere. It is a little unfair to call on him just now, immediately on his return to this room, but we would not be satisfied if he didn't say a word on the war and the disposition of the steel people to do what they can in furnishing steel or money or anything else. Mr. Schwab. (Applause.)

Mr. Chas. M. Schwab, New York: Mr. President and Gentlemen of the Iron and Steel Institute: I welcome this opportunity if for no other purpose than to add my quota of praise to the most admirable address that our President has ever given, at this, the Cincinnati meeting. I know that Judge Gary devoted very little time to this address, because he came on with me,—prepared the most of it while on the way, in the car, and I felt that it was the natural out-pourings of his own faith and his own heart that made the paper so valuable and so clear and so patriotic. (Applause.)

It is needless for me to reiterate what I am sure the other gentlemen have said during my temporary absence from the room with reference to patriotism, and the intention of the American Iron and Steel manufacturers to lend their all to this great effort in our country. Speaking for my own company, I can say to-day that of our 80,000 employees, and of our six hundred millions of contracts on our books, ninety per cent of the whole is for the United States government. (Applause.) I want to say that with all the energy, with all the talent that the organization of my Company has developed in the years gone by for their own individual profit and the advancement of themselves and their stockholders, that their efforts for the advancement and protection of their country have been re-doubled. (Applause.)

I feel very proud and very happy that fortune should have placed in my way the direction and chief ownership of a firm that at a time like this of great national crisis, is such a valuable asset. And, much as I like money, because I am always in debt, always striving to get out of debt—and as I said to my friend, Mr. Schmidlapp in Cincinnati, this morning, I have never been as heavily in debt as I am to-day—but much as I desire to be out of debt, much more do I desire that the future shall know that I have been connected with a company manufacturing iron and steel that has lent ninety per cent of its capital and efforts to the protection of its country. (Applause.)

And, what I have said of the interest with which I am identified can be said with equal emphasis of the interests of all the other steel manufacturers in this country, from the great steel corporation represented by our eminent President, clear on down to the very smallest one. (Applause.)

I want to diverge just a moment at this point to say that in our conferences at Washington, I have never seen anything so ably, so diplomatically, and so consistently conducted for the benefit of the iron trade, in general, and to the disadvantage of the corporation, than Judge Gary conducted for you, the iron and steel people of the Unted States, in Washington. He was the spokesman for us all, and he left us in a position that reflects credit upon the trade and we know that the people in Washington think far more of the iron and steel trade now than they ever have before. The disposition to be fair, the disposition to make sacrifices, and the disposition, above all, to show the people who rule the affairs of our country, that it was the intention of the iron and steel interests to do their part, and more than part, was made manifest by the masterly manner in which Judge Gary, and the gentlemen who assisted him, conducted the whole operation and he deserves the thanks of every man engaged in the trade. (Applause.)

One word more with reference to the Liberty Loan and with reference to the furnishing of the finances for the conducting of this great war. I subscribed both times, and subscribed liberally, but this time, I don't mind saying that I had to borrow every dollar that I subscribed. I don't know when I am going to pay it back! (Laughter.) I am not worrying about it, either. (Laughter).) The banks can do that! (Laughter.) I have borrowed so much, well, it is very well illustrated by a story, or, an incident, rather, that happened when I went to Mr. Krech of the Equitable Trust in New York, recently, to borrow some more money. The other day when I came to take up some of the new stock issued by the Bethlehem Steel Company, I had to borrow a lot of money, and I went to all the banks in New York. I didn't go to see any one, I went to all the banks in New York. There is no man happier in borrowing money than

I am! (Laughter.) Well, I said to Mr. Krech,—and the Equitable Trust is a pretty big bank,—"I want to know how much money I can get from you." He said, "How much do you want?" "All you can give me," I answered. "Well," said Mr. Krech, "specify how much you want." I named a pretty large amount. He shook his head and said, "You know you have already borrowed $2,000,000 here." I said, "Oh! Hell, I had forgotten all about that!" (Laughter.) I am glad that in this serious moment, there is still the good American laugh and humor left in all the people of the iron and steel interest. Mr. Carnegie used to say that a man never gave his best effort to anything if he didn't do it in a jolly frame of mind and in a good disposition. We seem to have entered this meeting at a crisis in our world's history, in a good frame of mind and in a jolly disposition. Let's make the meeting a memorable one in this the City of Cincinnati and the great State of Ohio. Let's just take one more hitch in our trousers, whether it be in the production of steel or in the contribution of money to this, our great, glorious country, that has made us all what we are. (Hearty applause.)

President Gary: I suppose there are others here who would like to speak and I will give you the opportunity. We would like to hear from you if we have to keep our convention going until banquet time. These speeches are splendid. (Pause.) If there are no other volunteers, I am going to make bold to ask everyone here who will furnish, so far as his influence goes, every pound of steel that he can produce and which the Government needs, to stand on his feet. (All stood.) It is unanimous. (Applause.) When this Institute was organized, I didn't believe I would ever have the feeling of exaltation and of pride in the Institute, and in being associated with its members, that I have experienced this morning. (Applause.)

Now, we must come back to the program. "Cincinnati and Its Industries," by Mr. Daniel B. Meacham, Partner, Rogers, Brown & Company. Mr. Meacham. (Applause.)

CINCINNATI AND ITS INDUSTRIES

Daniel B. Meacham

Partner, Rogers, Brown & Company, Cincinnati, Ohio

Mr. President and Gentlemen: Cincinnati greets you most cordially. We appreciate the honor conferred on us by the presence of this Institute, with the attendance of men so distinguished in the world of iron and steel.

Your patriotic support of the Government and your untiring, self-sacrificing efforts in assisting to prepare for and prosecute the war are well known. You are recognized as leaders in the humanitarian movements which are designed to improve the living conditions of your employees and to bring about a closer relation between capital and labor. Notwithstanding the many difficult problems facing you during these unparalleled times, we hope you will all remain tomorrow, and allow us to offer you a day of social entertainment.

The topic assigned to me is "Cincinnati and its Industries."

Every city has its individuality and its characteristics seem to be perpetuated. In a book entitled "Cincinnati in 1841," by Chas. Cist, is the following:

> The whole mechanic interest here has long since discovered that if they meant to supply this market with what formerly came from the eastern cities, it would not do simply to make as good work, for the weight of prejudice and fashion was against them, and unless they could show an article which was manifestly of better materials, more neatly or more strongly put together and finished in a higher degree, they felt it was impossible for them to overcome the force of the current. We then made it a settled principle at all hazards and sacrifices to drive out the eastern article. We knew that we had as good or better materials; that the right kind of workmen could be got, and as long as we met our expenses we must for so desirable an object wait for our profits until we could carry our point. The best workmen were accordingly engaged and brought out at high wages, and every effort made to instruct our apprentices on the latest improved patterns

and models, and in the course of a few years by the time our boys became journeymen, or went into business for themselves, we accomplished our purpose, and there is now not $5.00 worth of work brought out here where $1,000.00 was imported ten years ago. The whole competition here is who *can* make the best piece of goods, not who *will* make the cheapest one.

The determination in 1841 to make only the best has been consistently adhered to by our manufacturers, and that is the reason why Cincinnati products are famous throughout the world.

Cincinnati occupies about 72 square miles, with a population of 410,000. Including the contiguous cities on both sides of the river, the population of this industrial district is about 600,000. The United States census of 1910 showed that 79 per cent. of the people were native Americans, which was a greater proportion than that of any other large city in the United States. In 1910 male aliens over 21 years of age formed only $2\frac{6}{10}$ per cent. of the population.

The principal products of manufacture are: Machine tools, soap, rolling mill products, clothing, boots and shoes, printing and publishing, slaughtering and packing, furniture, lumber products, leather, sheet metal, special machinery, printing inks, chemicals, wood-working machinery and women's clothing.

A distinctive and unique feature of Cincinnati is its wide variety of substantial industries. According to the United States census of 1914, in this industrial district there were 2,623 manufacturing establishments, and these included 92 of the 264 industries recognized by the census. This diversity of industries is an exceedingly valuable asset to a city, and gives it advantages over one that is dominated by a single line.

The National Social Unit Organization made a careful and widespread survey and selected Cincinnati as the most typical American City and one in which the citizens of all nationalities and beliefs worked in best accord for social betterment, and its first experimental station is established here. Our people have a firm conviction that the real success of an industrial city rests chiefly on a well educated,

self-respecting working population. Many agencies are operating efficiently to bring about the results desired.

I could tell you of the historic past of our city and of its varied industries and achievements; of its place in the musical world; of its colleges and conservatories of music with thousands of students from the Great South and South-west; of its unexcelled Symphony Orchestra and its Music Festival, which was the pioneer of those now held in various cities. Regarding these Musical Festivals the highest authority writes:

> They have beyond question exerted a more powerful influence for musical culture than any other institution of their kind.

Our Zoological Garden is said to be the best in the country.

Our Exposition was the forerunner of the one held in Philadelphia in 1876, which had our Director in charge. Our Art School has started on their careers many of the most noted American artists. Our city owns a railroad, a profitable asset, which it had the foresight and sagacity to build to open up the South. It has a great municipal University, with thousands of students, which has introduced vocational methods now being extensively copied. Our new general hospital is one of the largest and best in the world.

The Cincinnati Water Works demonstrated to other river cities the possibility of eradicating that awful scourge, typhoid fever.

The verdicts of all the International Exhibitions, evidenced by the highest prizes during thirty years, are proofs that the Rookwood Pottery products are unrivaled.

I could emphasize the beauties of our residential sections and our 2,500 acres of parks, but some of these we expect to show you tomorrow.

An address like this is occasionally a vehicle carrying a heavy burden of statistics, but our Committee has guarded against too great a tax on your patience by presenting to each member a copy of "The Citizens' Book," which contains a series of carefully prepared articles by well qualified writers, covering the various functions of our City's life. It is used

by all our Public School teachers, and is, I think, an example in an educational line that other cities would do well to follow. Please read it and take it home to your children, so that the rising generation also may know more about the "Queen City." Allow me to call especial attention to its introduction:

> This is a book for the citizen; for the citizen who would know what his city was, what it is, and how it became so; for the citizen who wants his city to grow better, who has ideals for its improvement, or who is seeking for such ideals; for the citizen who is willing to work with others to help make Cincinnati a community which contributes the greatest possible good to each of its members.

I would like to say a personal word in order that our efforts may be appreciated. It has not been our intention to make our visitors here to-day dissatisfied with the cities in which they are, unfortunately, compelled to live. I purposely omitted hundreds of striking points that would convince you, that not only, as a place of business but as the ideal city in this country in which to live, Cincinnati is the place. (Applause.)

Sometimes I hear things said when I am traveling. A while ago, I was on a sleeper, and I heard two men in the rear discussing the merits of American cities, and one fellow said with a great tone of disgust in his voice, that he would rather live in Pittsburgh, even, than to live in Cincinnati! (Laughter.) People do come here—I am not saying this for publication, but I am telling you this confidentially—and say that Cincinnati is slow or ultra-conservative. Some of those men who come from places where the horn of self-congratulation is being sounded in their ears all the time, are in a position that reminds me of a story I have heard:

A friend of mine had a colored chauffeur, who went up Gilbert Avenue one day with his cut-out open, making a great deal of noise, and he was arrested for speeding and taken down to the station. Of course, he had to explain to his employer, and his explanation was like this,—"Law, now, Mr. Blank, that cop didn't know the difference between noise and speed!" (Laughter.) Now, here in Cincinnati,

if we don't make much noise, we are getting ahead and we are holding our advance, and we think that our progress is safe and sane.

In closing we again thank you for coming, and we hope that when you depart you will carry away many pleasant recollections. (Applause.)

President Gary: Informal discussion under the five minute rule. (After a pause.) If there is no discussion we will go on to the next paper, "Recent Installations of Large Electric Motors in Rolling Mills," by Mr. Samuel S. Wales, Electrical Engineer, Carnegie Steel Company. Mr. Wales. (Applause.)

MODERN ELECTRIC MOTORS IN STEEL MILLS

Samuel S. Wales

Electrical Engineer, Carnegie Steel Company, Pittsburgh, Pa.

In writing this paper, no attempt has been made to treat the subject technically or comment on detail design, as during the last eighteen months the scientific societies have given a great deal of attention to that side of the subject. There still seems to be a doubt among some members of the iron and steel industry as to the advisability of installing the motor in place of the steam engine or hydraulic cylinders, and I will attempt to briefly cite the steps leading up to the present wide-spread use of electric power in mills and the conditions which now exist and which call imperatively for its adoption wherever possible.

Early Difficulties

In the early 90's, the electric motor made its entrance into the steel works. At this time it was waging a doubtful combat for street railway supremacy with the cable and the mule, and many articles were being written proving that it was not as well fitted for the work as either of its competitors, which, at the time, was probably right.

The first use of the motor in steel mills was on detached machines, capable of independent movement from a fixed base, replacing the rope and shaft drives for traveling cranes, as all other machinery could be easily handled by older methods. This innovation was quickly followed, however, by its use on feed and transfer tables between roll trains and on charging and drawing machinery at reheating furnaces. Those early developments were made with such apparatus as the double reduction and single reduction street railway motors which were entirely unenclosed, and the first totally enclosed types which had sufficient stray field to make sparkless commutation an

impossibility. It is a great monument to the courage and confidence of all concerned that the electrification of steel works ever proceeded beyond this point, as at this time nothing could be seen ahead but trouble and delay.

About 1893, a new steel company was organized, and through the confidence of its projectors in the extreme flexibility of electric power and its ultimate reliability, it was made absolutely dependent on the electric motor in every department, even to the primary water supply for the whole plant.

Although the motor was the most convenient source of mechanical power ever used in the steel works, it was as yet unadapted to this special service. It had not yet reached any degree of standardization, but was just dividing itself into classes and into manufacturers' types of each class, while the mills were endeavoring to make certain standards of their own to adapt the railway motor to mill service, which was found to be much the more severe of the two. Indefinite increase in size to save the motor from damage did not accomplish this object, but developed the radical difference between it and the steam engine it displaced, its enormous overload capacity resulting in the destruction of parts of the mechanism driven by the motor.

A vast distance separated the designing departments of the Electric companies and the operating electrical men in the mill, and it was necessary for some of the mill electricians to take the stand that it was preferable to have special designs for mill work than to be obliged to rebuild the street railway motors, when received from manufacturers, to fit mill work. In this they were met half-way by the sales departments of two or three of the largest manufacturers of electric apparatus, who brought the two factions together and laid the foundation of the modern mill motor.

The Problem of Continuity of Operation

The basic requirement for a mill motor is constant service, as in case of failure of even one of the auxiliary units, the whole mill is stopped. This called for a more

rugged mechanical design throughout than the street car motor. Definite temperature limits were found necessary and embodied in all specifications sent out, as motors were at first sold on a temperature guarantee of as high as 100 degrees C on full load run.

Realizing the impossibility of absolutely continuous operation, the next consideration was to reduce the time lost by failure to a minimum. To accomplish this, it was very early discovered that the motors should be so constructed that the damaged parts, or the entire motor, could be readily replaced and no repairs attempted in the mill, and very careful attention to details was required to reach the present high standard which makes the modern mill motor the most convenient and dependable tool ever placed at the disposal of the engineer, as it is to-day.

Scope of Electric Motor Service

The electric motor has been applied to every class of machinery used in the production and finishing of steel, although only very recently has any one plant used electric power throughout.

At the blast furnace, electric power is now almost exclusively used in new construction, and is replacing steam and hydraulic power in existing plants, wherever the changes required are not so radical as to make the first cost prohibitive. The automatic skip hoist, the ore bridge and transfer cars are all so familiar as to need no description.

In the steel producing departments, cranes, charging machines, transfer cars, etc., are too common to attract notice, though some of the later applications, where the electric motor has replaced the hydraulic cylinder, such as ingot stripping, lifting furnace doors and tipping metal mixers and tilting furnaces, may still be of interest.

It is in the rolling mill, however, where the ruling spirit is mechanical power rather than metallurgical reactions, that the electric developments have naturally been most spectacular. From the early beginnings on cranes and charging machines, the motor now drives everything, in-

cluding the screw-downs and manipulator, applications which were long and stubbornly contested by the steam engine and the hydraulic cylinder. One of the later achievements of the electric motor is the direct operation of a large billet shear, abandoning the use of the usual heavy fly wheel and clutch, and starting the motor from rest for each cut. This shear has a maximum stroke of 8 inches and the entire apparatus reaches full speed while the shear knife is traveling ¾ of an inch.

Main Mill Drives

Having become successfully established for all the detail operations in the steel mill, the next natural step was to the main mill drive, which had always been the ultimate goal of both the mill electrical engineer and the manufacturer of electrical equipment. While the same flexibility and lack of reciprocating parts recommended it, several engineering drawbacks retarded the development for large units fully as much as the first cost of the motor itself.

Behind the motor was the power station, which was operated by the same general type of prime mover as that which the mill motor displaced, and although larger units could be used and shorter piping provided, still the engine troubles were really only transferred from the mill to the power house.

The gas engine, with its multiplication of comparatively small units and high first cost, although adopted at several plants to generate current for mill operation, did not seem to be the proper solution.

It would appear then that the greatest incentive to this development was the production of the large capacity, highly efficient steam turbine generator, followed by the increased size and efficiency of boiler units, which allows the delivery to the mill pinions, through the medium of the electric motor, of a mechanical horse-power at an expenditure of as low as 10 lbs. of steam per hour.

Since having an economical means of producing large amounts of electric power, the application of the motor to

main mill drives has been taken up vigorously, and great progress has been made.

Types of Mill Motors

The main mill drive motor is automatically divided into several types, by the class of mill to be operated, such as constant speed non-reversing mills for plates, billets, structural shapes, etc., where the product is sufficiently uniform to have one most efficient running speed; variable speed non-reversing mills, for wide ranges of products, such as merchant bar mills; and reversing mills, for blooms, slabs and universal plates.

The straight A–C induction motor is recommended by common consent by all the large manufacturing companies for the non-reversing constant speed mills, and as the simplest machine that will accomplish a given end is always the best, there is no criticism to be made on this choice.

For the variable speed non-reversing mills, there is considerable divergence as to the method of producing the changes in speed, i.e., The Kraemer System, in which the regulating apparatus is mechanically connected to and at times supplying part of the mechanical torque to the rolls, by means of the regulating current, and which can be designed to operate either above or below, but not at synchronous speed, and The Sherbius System, in which the regulating apparatus is mechanically separated from the main motor, returning its surplus power to the line, and which can be run at any point below, through and above synchronous speed.

For many mills where only small ranges of speed change are required, either of the above systems should be equally satisfactory, though it would seem preferable to do all the driving with one motor rather than supply 5 per cent. or 10 per cent. of the mechanical power through the shaft of the regulating motor, as is the practice in The Kraemer System. Where wide ranges of speed are called for and the motor may be required to operate at or near synchronous speed, the Sherbius System would appear to be the most adaptable, for

with the Kraemer System there will always be a region varying from 2 per cent. to 5 per cent. on each side of synchronism where the motor is unstable.

For the reversing mill, all are agreed on the fly-wheel motor generator set (the Ilinger System), but some difference of opinion is still apparent as to the main motor, whether compound or shunt wound. It is somewhat difficult to reason out the advantage of the compound winding on a motor for this service. It appears doubtful if there is sufficient time when the ingot enters the rolls, and the shock is thrown back on the motor, for the compounding current to overcome the reluctance of the magnetic circuit of the machine so as to have any appreciable effect in cushioning the shock. It is quite apparent, however, that in later passes, after the piece is well in the rolls, and the motor is called upon for power and speed, that the compounding will come into full action with a consequent decrease in speed, and a reduction in the tonnage output of the mill.

It must of course be thoroughly understood that this compound winding is entirely independent of the inter poles and the main pole-face windings, which are universally used by builders of large reversing motors for securing sparkless commutation by controlling the distribution and density of the magnet field of the motor.

There is some difference of opinion as to the proper basis for rating these large motors, which is the cause of much trouble and annoyance to engineers and purchasers, as it is difficult to arrive at a comparative basis as to price and capacity. One manufacturer may rate his machine as the maximum output based on its greatest ampere-carrying capacity with sparkless commutation, which may be three or four times the normal mill rating based on 35 degrees rise in temperature of any part of the machine. Another may rate on a definite temperature rise. In the absence of a definite basis of comparison, the purchaser is thrown back on the competitive manufacturer's guarantee that, regardless of ratings, their machine will do the work. When handled in this way, all specifications drawn up, and preliminary engineering work done by the purchaser are wasted.

An injustice may thus be done a company bidding on the size of apparatus asked for, but who could have possibly given a lower price on the size finally purchased, and the purchaser may buy something which, while adequate for past practice, may not have the margin desired or intended in the original plan for future developments.

On all auxiliary mill motors, modern practice is to guarantee a maximum temperature rise of 35 or 40 degrees C. for a continuous full-load run, and it would seem that if such a standard is considered a necessary basis of safety after twenty years of mill electrical engineering, we should not abandon all precedent, for a manufacturer's performance guarantee, which must be more or less intangible and cannot be measured. The best and most faithfully kept manufacturer's guarantee does not and cannot reimburse a mill owner for loss of time and tonnage while a mistake is being made good, and the mill electrical engineer is not true to his responsibilities if he allows any modification of what experience has dictated as the line of safety, and it is to be hoped that all manufacturing companies and purchasers will be able to reach some equitable agreement on this vital detail.

Cost of Equipment

Although frequently stated offhand that the cost of equipment for electrical drives, especially for Reversing Mills, is so far in excess of the cost for steam as to offset any saving in operating cost that may be shown, the statement does not appear to be borne out by a close analysis of the subject. For the straight running mills, the comparison of first cost of equipment may be less favorable to the electric drive than with the Reversing Mill.

With the steam drive, the boiler house must be located quite near the mill to avoid long steam lines, which often involving costly engineering details, does not tend to concentrate the plant. If condensing engines are used, the large amount of water required may have to be carried for a considerable distance to the engine. All of this is avoided with the Electric Drive, as the power station and boilers may be located

at the most convenient place, not necessarily inside the plant, where fuel and water can be supplied at a minimum cost.

The large reserve in boiler capacity which must be provided to take care of the peak loads in an all-steam plant, will in most cases over-balance the first cost of the electric equipment. Even with the best arrangement of boiler houses and their complete interconnection, they must be in effect very widely separated when compared with the compact unit representing an electric power plant.

In most cases it will be found that from three to four times the boiler capacity will be required for the same output with an all-steam equipment than with a completely electric-driven plant, the comparative first cost of which can be readily appreciated. An all-steam plant could be cited which could operate an electric power station four and a half times its total power requirements with the steam it now consumes.

In many cases, on non-reversing mills, 1,500 to 2,000 pounds of steam are required per finished ton for average sizes of structural shapes which, if reduced to K.W. on the high basis of 15 pounds per K.W. hour, would represent 100 to 133 K.W. per ton against a probable figure of 30 to 35 K.W. per ton for a similar electrically-driven mill. In the above figures, the peak loads have not been considered, as in both cases they will be passed back to the boiler plant, the figures given representing the total power used for at least a week's run.

On reversing mills, the actual consumption of steam with electric drive will probably be about half of the equivalent steam drive, but in this case the peak load must be taken into consideration, as it may represent from four to five times the normal power required and in the case of the steam-reversing engine, it must be absorbed by the boiler. With the electric drive, this shock is almost entirely taken up by the motor generator fly-wheel set which is interposed between the line and the main motor so that on an average only one-seventh of the peak load is thrown back on the boiler plant.

Where a saving of three-fourths of the coal used for power

generation can be shown, the substitution of electric power for steam becomes as much an economic necessity as the use of the by-product coke oven.

Costs of Operation

The comparison of actual money costs in the operation of electric motor with other methods is difficult and more or less unsatisfactory on account of the differences in cost of power, work's organization and accounting systems, so that all comparisons here are made on a basis of kilowatt hours per ton of product. Even this is only approximate as the applications of electric power vary in different plants and the finished product, sizes of ingots, drafts used, temperature and composition of steel rolled all enter into the main Roll problem. However, some approximate figures have been arrived at which are given below, although probably subject to further modification as more data becomes available.

Kilowatt hours, per ton of pig iron produced........10.25
Kilowatt hours, per ton of Open Hearth steel produced 4.15

In the rolling mills, the diversity is so great as to make anything like accurate estimating equivalents practically impossible but the following will give some idea of what to expect, although they are not directly comparable.

Non-reversing Mills, Electric Drive

Raw Material	Finished Material	Main Rolls K.W. hrs. per ton
7″ x 7″	30-pound Rail	60
6″ x 7″	3½″ to 8″ angles	33
22″ x 22″	Standard Rail	46
20″ x 24″	4″ x 4″	31

Reversing Mills, Electric Drive

20″ x 20″	5″ x 5″	25.5
20″ x 20″	8″ x 8″	17.0
18″ x 20″	4″ x 4″	26.0

As the mill requirements can be readily determined, these figures are only indications and each problem should be the subject of special calculation.

Historical

The first large installation of electric motors was made at Edgar Thomson Works in 1905, for rolling light rails, where power equal to 3,000 kilowatt was generated and transmitted for a short distance only at 250 Volts D. C., the equipment being in perfect operating condition to-day. The latest installation was at Homestead Steel Works on a 110 inch Plate Mill, where a 25 Cycle alternating current equivalent to 3,000 kilowatt is transmitted at least three miles at 6,600 Volts. This mill was started October 15th of this year, less than six months after breaking ground, the electric drive being finished in five months from placing of the order.

Between these two dates, there have been installed in the United States, 170 non-reversing rolling mill drives of over 1,000 horse-power capacity.

The first large reversing equipment using the Ilinger System in this country was installed at Illinois Steel Company in 1907, after which only two equipments were built in the following ten years. The rapid development of this class of equipment began in 1916, for there are on record fifteen plants from 8,000 to 15,000 horse-power maximum rating, operating or to be installed during 1917, and up to date five equipments from 9,000 to 19,000 horse-power for 1918 delivery.

It would therefore appear that the electric motor has proved itself to be wholly reliable, extremely adaptable, not excessive in first cost, and very economical to operate, and there should be no question as to its general adoption. (Applause.)

President Gary: Discussion, by Mr. Wilfred Sykes, Electrical Engineer, Westinghouse Electric & Manufacturing Company.

MODERN ELECTRIC MOTORS IN STEEL MILLS

Discussion by Wilfred Sykes

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Mr. Wales' paper is an interesting review of the position of the electric motor in the steel mills of today. The very rapid development in the use of electricity within the last few years, which has made the motor driven mill so common often obscures the fact that the development is only of comparative recent date.

Mr. Wales has touched upon the reversing mill drive and it might be of interest to review the development of this type of mill drive. The first electrically driven reversing mill was installed in Austria in the summer of 1906 and put in operation the same year. This mill was located at the Hildegradehutte and was a combined blooming and structural mill. The motor consisted of three units and developed a maximum of 10,000 H.P. The successful operation of this installation from the beginning stimulated very greatly the demand for electrically driven reversing mills in Europe, and in the succeeding years, quite a number of installations were made. At the beginning of the War, there were about fifty (50) reversing mills in Europe. In the United States, we were working on the same problem independently, without knowledge of what was being done in Europe, and in the beginning of 1907 the installation of the reversing, 30 foot universal plate mill at South Works of the Illinois Steel Company, Chicago, was completed.

Some Recent Installations

This installation being completed within a few months of the starting of the first installation in Europe, afforded an interesting comparison, and in general it can be stated that both installations fulfilled the estimates of their designers. The Illinois Steel installation differed in a number of details from the Hildegradehutte plant, but the scheme

adopted was identically the same and the difference was more in details of construction than in principle. In the United States the steel business underwent a period of depression, so that no new installations were considered for several years. In 1909 the Algoma Steel Company decided to install a new blooming mill and adopt electric drive. This installation was not completed, however, until 1911, and for several reasons was not the success that might have been desired. In 1912 the Steel Company of Canada at Hamilton, Ont., decided to build a new mill, part of which equipment was to be a 34-inch blooming mill. After a considerable investigation of the question of power supply, cost of operation, first cost, etc., it was decided that the mill would be driven electrically. This installation was put into operation in March, 1913, and was operating entirely successfully at the time when the steel industry felt the need of an increase in blooming mill capacity. I believe it is no exaggeration to state that it was the successful operation of the mill of the Steel Company of Canada that made possible the rapid development of the electrically driven reversing mill in the United States from 1913 to date. This installation was the one with which the older practice was compared and the obvious advantages of the electrically driven mill were readily appreciated. After an investigation of the Steel Company of Canada's mill, the Bethlehem Steel Company ordered an equipment for their 35-inch blooming mill at their Lehigh plant. Somewhat later, the Central Steel Co., of Massillon followed the same procedure and theirs was the first electrically driven blooming mill to be put in operation in the United States. Since that date, the data that has been available from these installations has been of such a conclusive nature that I don't believe any stream driven reversing mills have been installed.

There are, of course, a great many details of construction that have been given very careful thought which have aided greatly in the successful development of this type of equipment. As a preliminary to the design of these equipments, a careful study was made of mill operating conditions, so as to obtain the viewpoint of the mill operators.

In the period from 1907 to 1912, we made many investigations of mill characteristics with the idea that when the time came to make such an installation we would at least understand what was necessary from the mill standpoint. It was our opinion that we should utilize the characteristics of the electrical equipment to the best advantage and not attempt to only duplicate the characteristics of the steam engine. In other words, we should study the requirements of the mill and see in what way the characteristics of the electrical equipment could be best adapted to the work. It is very necessary that this distinction should be kept in mind in considering the development of electrically driven mills as the motor is handled quite differently from an engine.

Winding the Reversing Motor

Mr. Wales has mentioned the fact that there seems to be a difference of opinion regarding the type of winding of the reversing motor. His questions on this subject can perhaps best be answered by a review of our experience. The first reversing mill at Hildegradehutte had the equivalent of a compound winding which was used so as to increase the stability of the electrical equipment and at the same time to dampen the shocks that might be thrown on the mill during rolling. It might be claimed that no characteristics of the electric motor could affect the shock thrown on the mill equipment. I do not think this is true, as it is obvious that if there is introduced a certain element of flexibility which will enable the mill to give way slightly before the shock of metal entering the rolls, that it will be easier on the equipment that if you had a motor that independent of the load would continue to drive the mill at the same speed. The question of stability is one that is closely associated with the controlling system used. With machines designed to change their speed rapidly, as they must be for this work, there is a tendency for the current to change very rapidly with any sudden or unskilled operation of the equipment. With a shunt motor, this characteristic is at times decidedly embarrassing, and is very marked in some

installations. A compound machine inherently, without the intervention of any controlling device, tends to dampen such rapid changes of current. These very rapid fluctuations cause sparking, due to the rate of change of current being such that the magnetic flux due to the compensating windings cannot follow the current change, and also are liable to cause severe flashing due to the swings exceeding the commutating limits of the machines. The first installation at Illinois Steel on plate mill, had shunt wound motors and the operation was such that when the equipment for the blooming mill of the Steel Co., of Canada was built, shunt wound machines were adopted. A very careful study was made of the Steel Co., of Canada's installation to determine how its characteristics matched the mill requirements, and it was found that in the hands of unskilled and careless operators the shunt machine was apparently liable to cause more trouble in the way of commutation difficulties and also by the opening of the circuit breakers, thereby delaying the mill, than had been experienced in some of the European installations with which I was familiar. There was also lacking the flexibility which we felt could be obtained and which would be desirable. The study of the test records indicated that the compound machine would probably give less trouble and would be better suited for our operating conditions, although somewhat more expensive to build, consequently the reversing motor for the Bethlehem Steel Co. was designed as a compound machine, and a study of the operation of the two plants, with a knowledge of all the facts, I believe warrants the change. Since that time all the installations with which I have been connected have had compound wound motors. This point is not of vital importance, as either shunt or compound machines will operate satisfactorily, the difference being that the compound machine from a general operating standpoint, will probably give less trouble and will cause fewer delays due to circuit breakers opening, and will be easier on the mill than the shunt machine, and we therefore consider it an improvement made after we had built and operated shunt wound motors.

The Rating of Motors

The next point raised by Mr. Wales refers to the rating of these motors. It is common practice to rate electrical machinery by the load it will carry continuously with a certain temperature rise in the windings. There are classes of motors, however, that are rated on the load they can carry for short periods with a certain temperature rise, or without distress, such machines being used for hoists, tables, screwdowns, manipulators, etc., in steel mills, and in other industries where the capacity to carry a load of short duration is of more importance than the continuous rating which may be never utilized. Experience here and abroad backed up by a considerable number of tests made in different plants, shows that the reversing mill motor has its design fixed by its capacity to care for the very high momentary loads that it has to carry during some of the rolling operations and that the heating capacity is seldom a factor, in fact the heating capacity can be sacrificed to a certain degree if the machine can be improved from a standpoint of electrical or mechanical design. The peak load capacity fixes the dimensions of the machines and the natural relation that exists gives a heating capacity in excess of that required if an ordinary construction is used. In installations which I have been associated, the heating capacity has been deliberately sacrificed to improve the mechanical design of the machines, as we have found that even then we had an ample margin for the operation of the mill, and the temperature of the windings was not the limiting feature, but we have never found that we had more peak load capacity than could be utilized after an operator found out the capabilities of the equipment. We have therefore always rated our equipment on its capacity to carry peak loads for a short period, such as met with in reversing mills, as this is a measure of the machines to perform rolling mill work. To rate a machine on its continuous capacity while an indication of its ability to perform certain test conditions, is of no value as an indication of its capacity to drive a reversing mill. It would be a simple

matter and would cheapen the construction to increase the continuous rating of our reversing motors at least 50 per cent. using the same physical dimensions, but as our experience over a period of many years indicates that it is not necessary, we believe that it is better engineering to balance the electrical and mechanical design making the motor which has such severe mechanical stresses to withstand as strong as possible. In the case of the generators where the mechanical stresses are only those due to the electrical loads, ordinary constructional practice is followed and in general the heating capacity which however cannot be utilized, is at least 50 per cent. above that of the motor, the design being fixed by the peak loads that must be carried.

At various times, there has been a question in the minds of mill engineers as to the methods of connecting motors to the mills. In the early stages of the development, the motors were directly connected but this required large and expensive machines, some characteristics of which were not altogether desirable from an electrical standpoint. Since the development of the machine cut herringbone gear and its successful application to rolling mill work, ample experience has been gained to show that the question of gearing from an engineering standpoint presents no serious problem, and it is thoroughly reliable. This has enabled us to use higher speed motors, thereby obtaining better performance and lower costs.

We have felt that the electrical engineer would have to assume the responsibility for the proper design not only of the motors used for driving the mills, but also of the methods of connecting the motors to the mills, the proper design of flywheel and the best type of control, as all these factors must be combined to make a successful installation. It has therefore been our practice to either supply or make recommendations for the whole installation, and the uniformly successful results obtained justifies the belief that this practice has aided materially in the successful development of the electric drive for rolling mills. I do not believe the same results could have been obtained if the manufacturers of electrical machinery had not made such studies

of mill conditions as to enable them to design the complete drive, and that there would have been a considerable percentage of mis-applications. (Applause.)

President Gary: Further discussion by Mr. K. A. Pauley, in the absence of Mr. Rushmore.

MODERN ELECTRIC MOTORS IN STEEL MILLS

DISCUSSION BY K. A. PAULEY

Power and Mining Engineering Department, General Electric Company, Schenectady, New York

It is safe to say that the resources of few, if any, of the industries of this country have been more severely overtaxed than those of the steel industry. The mills have been called upon to deliver their maximum output and in many cases under most exacting specifications. Extensive additions to existing mills as well as the building of entirely new works have been necessary to at all keep pace with the ever-increasing demands for increased tonnage. In this rapid growth electricity has played a very important part in every branch of the industry, but perhaps no where to so great an extent as in the rolling mills, and we are indebted to Mr. Wales for his very timely resumé of the early history of the application of electric power in the rolling mill and the present status of some of the problems of main roll electrification.

In discussing Mr. Wales' paper I wish to refer first to the question of variable speed drives. Both the Kramer and the Scherbius systems have their respective fields of application and the choice between the two can only be made after due consideration of the special conditions affecting the problem. However, in general, because of the greater first cost of the Kramer system, the instability of the main motor near synchronism with this system, and the consequent lack of control over this range—a difficulty not experienced with the Scherbius system, the difficulty if not the impossibility of obtaining power factor correction with the Kramer system although readily obtainable with the Scherbius system together with the possibility frequently with the Scherbius system of operating the rolls at the speed required for a large part of the production at an efficiency much higher than is possible with the Kramer system have

led to the almost universal adoption of the Scherbius system of control for the variable speed operation of main rolls.

With reference to the question of compound versus shunt motors for driving reversing mills, I certainly agree with Mr. Wales, that compounding the roll motor in no way relieves the mill or motor of the mechanical shocks. When the ingot hits the rolls the roll motors slow down until the combined work delivered by the motor armatures in slowing down and the torque developed by these motors is sufficient to carry the steel through the rolls. The stored energy in the armature acts instantly and delivers the initial blow, whether the motor is shunt or compound wound.

Compounding reduces the overloads on the electrical equipment but does so at the expense of production as it slows down the rolls while the piece is being rolled. We must appreciate that rolling mill conditions are extremely severe, take the "bull by the horns" and design equipment to withstand the overloads and mechanical vibrations incident to rolling, and if this is done there will be no need for compounding the roll motors.

The third and last point which I wish to discuss is that of the rating of rolling mill motors. Motors should be rated by their continuous capacities, which is a measure of their ability to produce tonnage, and by their maximum overload capacity, which is a measure of their ability to withstand the high momentary overloads of the individual passes, and no rolling mill equipment is properly defined without the specification of these capacities. Altogether too much emphasis has been placed on the maximum capacity, and any such rating for these motors which includes only the maximum horse power without a time or speed qualification is not only contrary to the recommendations of the American Institute of Electrical Engineers, but extremely misleading and flexible, and no purchaser is safe in assuming that specifying the maximum horse power at any given speed, or series of speeds, alone protects him against obtaining an equipment inadequate to meet his requirements. For this reason we have always insisted on giving, for various speeds, the continuous ratings of our

reversing mill equipments, together with their every ingot maximum capacities and emergency overload capacities to take care of unusual peak loads, and it is very gratifying to us to find that most of the engineers of the larger steel companies appreciate the importance of doing this and insist on curves giving the continuous, as well as the maximum load capacities in purchasing their equipments. (Applause.)

President Gary: "Iron and Steel Scrap," by Mr. W. Vernon Phillips, of the Perry Buxton Doane Company, of Philadelphia. Mr. Phillips.

IRON AND STEEL SCRAP

W. Vernon Phillips

The Perry Buxton Doane Company, Philadelphia, Pa.

I have been asked to address you on a subject which Mr. Farrell tells me has never before been put before you, namely, Iron and Steel Scrap, and I feel very fortunate in having the opportunity to tread on virgin ground. The subject, however, is such a broad one that I can only touch upon certain features, but I hope it will leave the way open for further and more scientific discussions, which I am sure will be both interesting and helpful to both the producer and consumer.

For the present my purpose shall be to acquaint you with the great importance of this too lightly regarded business—we can not call it an industry, though it is fast approaching that stage.

Importance of the Business

But first let me point out its importance as a business. For instance, it is second only to pig iron in point of tonnage. The total consumption of iron and steel scrap in the year 1916, over and above that made by the consumer, was in excess of 12,000,000 tons, exclusive of cast iron scrap and material used for chemical and other unusual purposes, also exclusive of the large tonnage of borings and turnings used on the blast furnaces, all of which would make an additional 2 to 5 million tons, but we are without figures, or the present opportunity to secure figures, on this tonnage; so we will confine our consideration for the present to the 12,114,000 tons consumed in 1916, which represents 9,646,617 tons of iron and steel scrap melted in open-hearth basic and acid furnaces including a small tonnage which was used in electric furnaces. Of the balance, approximately 2,000,000 tons was worked in rolling mills by the various methods employed, namely, busheling, puddling, piling and direct

rolling into bar iron and soft steel, while over 600,000 tons was converted by mills rolling old rails down to lighter sections, to angles, to concrete bars and including axles, shafting, etc., rolled to steel bars.

During the present year the increased open-hearth capacity will probably have called for at least 2,000,000 tons more scrap than in 1916, in fact, due to the inability of pig iron to keep up with the demand, such enormous calls were made on the scrap business that prices were advanced nearly 100 per cent. However, this had the desired effect and scrap was brought to the consumer from the remotest parts of the country and including many points out of the country, so that the price quickly receded with the satisfied demand.

As I said before, we have no means of accurately estimating the tonnage, but from the figures available, we can safely say that during 1917 there will be consumed over 15,000,000 tons of all grades of iron and steel scrap, valued at about $400,000,000, in fact, many of you will probably be surprised to learn that there are single companies doing an annual business of over $50,000,000 and a great many whose turnover exceeds $10,000,000.

You will see by now that my prime object is to impress you with the importance of this business, for the simple reason that it has been so hopelessly misunderstood and it was not until the United States entered the War and began to take serious stock of itself that the subject was considered of sufficient importance to be recognized. As an illustration, when the Sub-committee on iron and steel scrap was appointed in connection with the Council of Defense, one paper seriously remarked that even the humble scrap dealer was to be called on for help.

Consumption of Iron and Steel Scrap

From recent compilation of figures, we gather the following information:

Eliminating Foundry, Malleable, Forge and Alloyed Pig Iron, we show the following production available for use,

which apparently requires a minimum of twelve million tons of wrought iron and steel scrap to keep the mills operating at their 1916 capacity. In these figures we do not take into account the fact that blast furnaces are now using large tonnages of material which formerly went into open hearth furnaces, such as borings, turnings, etc., and are thus reducing the available supply for open hearth practice to that extent. Nor have we taken into consideration any cast scrap used by foundries, as we feel this may be dealt with separately.

1916

PRODUCTION		
Basic Open Hearth Ingots		30,238,978 Tons
Bessemer Steel Ingots		10,916,248 "
Electric Steel Ingots		126,048 "
Total		41,281,274 Tons
PRODUCTION		
Basic and Bessemer Pig Iron Produced	32,106,544	
Basic and Bessemer Pig Iron Imported	135,349	
	32,241,893	
Less Pig Iron Exported	607,236	31,634,657 Tons
Outside Steel Scrap Consumed		9,646,617 "
Rolled Iron		1,822,571 "
Rails Re-rolled to Rails		144,826 "
Rails, Axles, Shafting, etc., Re-rolled to Bars		500,000 " *
		12,114,014 Tons
Scrap Exported	212,675 Tons	
Scrap Imported	116,939 "	
		96,636
Total Consumption of Wrought Iron and Steel Scrap		12,210,650 Tons

With the exception of the figure marked (*) all tonnages used are taken from the American Iron and Steel Institute and Government records and we believe are dependable, though the figures on the export of scrap we know to be very much under the actual amount.

In addition to the consumption above shown, there is a large tonnage going into various manufactories not consumers heretofore, such as borings and turnings for chemical purposes, adjuncts to munition plants and die manufac-

turers, besides the large quantity of scrap which is being reclaimed and utilized in place of new material owing to the fact that it is very difficult to obtain new equipment such as plates, shapes, relaying rails, etc. We assume this would represent a minimum of three hundred and fifty thousand tons additional.

The Sources of Supply

There is also an erroneous impression regarding the source of iron and steel scrap and it is likely that no half a dozen men in the industry would figure the same way, but it is the opinion of authoritative judges that 25 per cent. of all the iron and steel scrap is produced by the railroads, 40 per cent. by the industrial plants in the form of new crop ends, structural crops, ship plate, stampings, turnings and borings, the other 35 per cent. is shipped by scrap yards of which probably one-half consists of railroad and industrial scrap sent to the yards to be sheared and prepared, leaving 15 per cent. to 20 per cent. which is collected by the junk dealers. But while the collection of old agricultural house and city scrap represents a comparatively small portion of the entire production, it is at the present time a most important part, as *that* is the only source which can be increased. The railroads are producing less, due to labor conditions; industrial plants can only produce scrap in proportion to the amount of the steel they receive; while all scrap which comes from replacements is smaller in volume, due to the great difficulty in replacing machinery or equipment of any kind. Besides, we are shipping millions and millions of tons of our steel out of the country, from which we are getting no scrap and will get no scrap; and, in addition, the trade is being called upon to ship thousands of tons of scrap itself. Italy in particular, has been starving for steel scrap, and there has already been shipped out over half a million tons. The Government has taken a hand in this, as it will in many ways, to regulate this business during the War; but if the War keeps up long we shall soon reach a point where iron and steel

scrap will become a vital matter, and I want to use this opportunity to impress all of you with the importance of regarding this subject seriously.

The Value of Scrap

The value of iron and steel scrap is in exact proportion to the value of material it replaces. Thus No. 1 steel scrap is based on basic pig iron and over the last fifteen years has sold at approximately 10 per cent. less than the delivered price of pig iron at Pittsburgh. In all other sections the percentage below pig iron has been greater, due to the increased cost of delivering pig iron and the fact that Pittsburgh is usually the highest market for steel scrap, it being the largest consumer and a relatively smaller producer. All other grades of steel scrap down to light turnings are worth their relative value to No. 1 steel scrap; but scrap does not always bring its intrinsic value as it is entirely based on supply and demand. Steel scrap has frequently sold above basic pig iron, though not in the last few years, and there has usually been sufficient scrap to keep it well below its parity. Thus we come back to the same point that scrap is worth only the price that it will bring. It has no manufacturing cost basis.

The Need of the Dealer in Scrap

You are all either consumers or producers of scrap. There are millions of producers and hundreds of consumers, who are, in turn, served by thousands of dealers. The hundreds have always used this great advantage to discourage and discredit the thousands by the very simple and though probably innocent expedient of buying something they want but something the dealer can not always deliver. This is at the root of all the so-called dishonesty in the scrap business. In normal time the competition is very severe and the scrap dealers go beyond their own powers in their efforts to please the buyer.

Scrap is not produced, it is a by-product or a discard of something and it can rarely conform to specifications

calling for strict sizes, weights, shapes and characters, especially under existing circumstances, when the stock piles of the country have been depleted, with labor scarce and unwilling, and with shipping facilities so limited.

The greatest good a buyer can do to-day is to buy what the dealer or producer has to sell, rather than to buy something which he has to try to get out and get.

Scrap has no value without a demand. For instance, when I was in the tin plate manufacturing business about twenty years ago, we were always at a loss to know what to do with our tin plate clippings or what is known as tin snap, and we paid money to have it hauled to the dump. Within a few years, Dr. Goldschmidt discovered a method of detinning, producing chloride of tin and oxide of tin and removing 97 per cent. of the metal, leaving the residue of steel sufficiently free from tin to be used in the open hearth furnace, the black sheet trimmings left being hydraulically compressed. The detinning business has greatly expanded; tin scrap became a commodity and ever since has had a market value.

Helping the Government

The larger dealers in the iron and steel scrap business met immediately after the declaration of War and formed an association known as the American Board of Scrap Iron Dealers, for the sole and specific purpose of furnishing the Government with help and information. Up to the present time the Sub-committee of the American Iron and Steel Institute has been co-operating with the various governmental boards and commissions; but now that the plans are to be put into actual operation, the American Board of Scrap Iron Dealers is about to take up the work of establishing and maintaining bureaus for the purpose of assisting in that most serious of questions, transportation, working in harmony with the American Railway Association, and also for the purpose of eliminating in so far as possible the question of rejection, and I speak for them in asking the heartiest co-operation of all the consumers. Do not reject unless you have to. Do not reject for technicalities.

Do not reject because the price has declined, but when you find what is known as a doctored car (for the information of the uninitiated, a doctored car contains good scrap on top and poor scrap underneath) do not take it under any circumstances, and if possible, do not let anybody else take it; have it returned to the shipper and report him to the bureau. There are men in the business who give it a bad name and this is a good time to get rid of all bad men.

Some Interesting Features of the Scrap Business

I have been talking in a purely elementary manner. I have not touched on the grades, classes and specifications nor on the peculiar nature of this most interesting business. It is unlike any other large business. The competition is to buy not to sell. There are a hundred different kinds of iron and steel scrap, and possibly a hundred different users. It is the business of a scrap dealer to know what each mill uses and wants and what each producer makes. People often ask why the seller does not buy back the scrap from his own steel; but only in rare cases can he use it in the form it is made, and even then some other user needs it more than he does and is willing to pay a higher price. There is a use for every kind of scrap made; and while economists are making this wonderful discovery, it has long been known to the scrap dealer and there is no such thing as waste to-day.

The successful scrap dealer must not only know his own business but that of each of his consumers, and the better he is informed the better he can serve them. He has yards all over the country to-day that are really manufacturing plants representing millions of dollars of investment in land, buildings, shears, drops, cranes, presses, locomotives, magnets, etc., many of these yards representing an outlay of several hundred thousand dollars each. These yards are steadily growing and they will soon be supplying 50 per cent. of the scrap requirements of the country. The old idea of storing scrap and selling on a high market has disappeared, at least for the present. The un-

prepared scrap comes in at one end, so to speak, goes through its various operations and goes out the other end prepared and ready for the charging box, rolling mill or foundry, as the case may be.

I fear I have tired many of you, but the subject is such an endless one that I fear it must wait for a future time when it may be discussed under its various headings. I would like to tell of the wonderful, yet unorganized, system by which this great volume of material reaches its markets, of the methods of financing in which many dealers virtually act as bankers, of the short selling and long buying, and of many amusing incidents in connection with the ignorant, small dealer's efforts to market his material, also of the methods employed in the scrap business abroad, particularly in England, and Germany, where scrap has become of such prime importance as a result of the War, but I fear that I have already overstepped my privilege and must thank you for the interest you have shown in this rather general description. (Applause.)

President Gary: This important branch of the industry has a very intelligent and worthy representative in Mr. Phillips.

After some announcements by the Secretary, the Institute adjourned until 1:30 P. M.

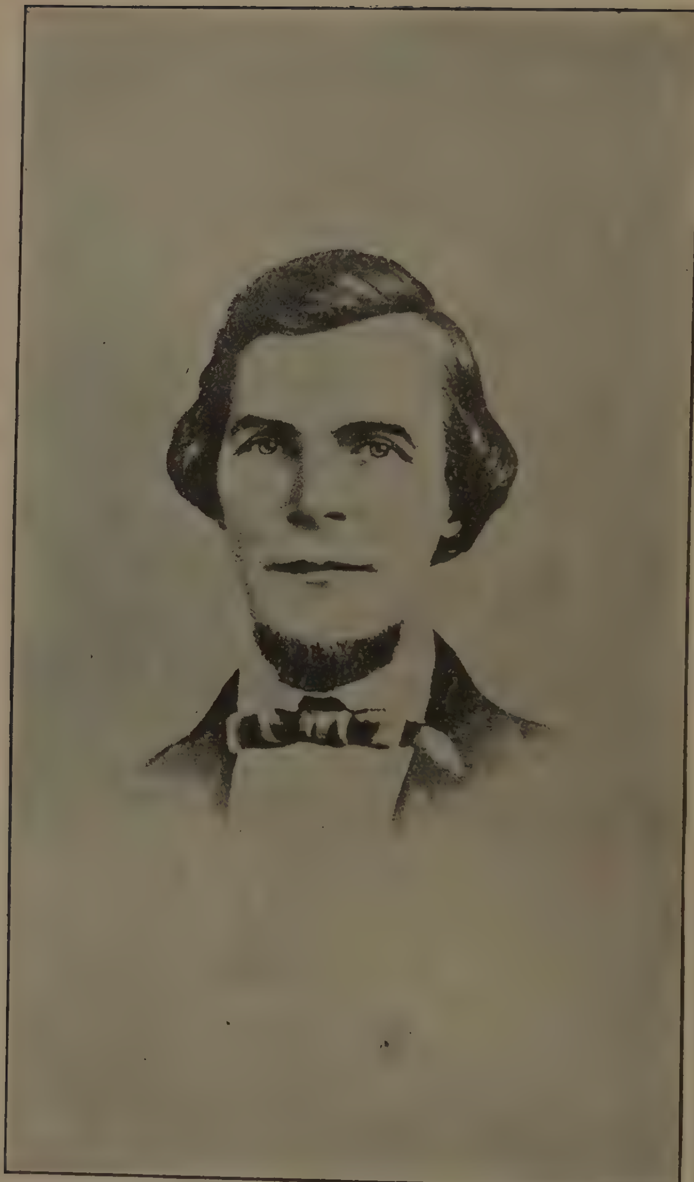
JOSEPH G. BUTLER, Jr.

AFTERNOON SESSION

President Gary: Gentlemen, you are to have the very great pleasure of listening to an interesting paper by our old and much beloved friend, Mr. Joseph G. Butler, Jr. He has prepared this paper with a good deal of care and after considerable study. The paper, as originally prepared by him, was a pretty long one, but no longer than the subject necessitated. A part of this address has been temporarily emasculated. The address will be published in full in the Year Book. I have no doubt, during the half hour that we have finally decided we must give him, Mr. Butler will comprehensively cover the situation. His paper is entitled, "Fifty Years of Iron and Steel." The first five of those years, Mr. Butler writes from information he has gathered from the books and from the older people of his neighborhood. The other forty-five years he has gathered from experience, commencing very soon after his birth! (Laughter.) I have very great pleasure, not to introduce, but to announce, a distinguished citizen, Mr. Joseph G. Butler, Jr. (Applause.)

Mr. Joseph G. Butler, Jr.: After that introduction, I am afraid your expectations have been raised a little too high. As Judge Gary has said, this paper has been cut in two, so that it will really be twenty-five years of iron and steel, instead of fifty. But I am very glad to see so many here. I was told this morning that I was going to compete with the horse races this afternoon and for that reason it is particularly gratifying to see so many and I appreciate it very much. I don't like the idea of reading, but I will have to do it. I generally like to get up and talk, just as Mr. Schwab does, but I am going to read this to you, and I am going to see that I get my half hour, too! (Laughter.)

President Gary: The time has commenced to run! (Laughter.)



JAMES WARD

With William Ward and Thomas Russell, He Built at Niles in 1842, the First Rolling Mill in the State of Ohio

FIFTY YEARS OF IRON AND STEEL

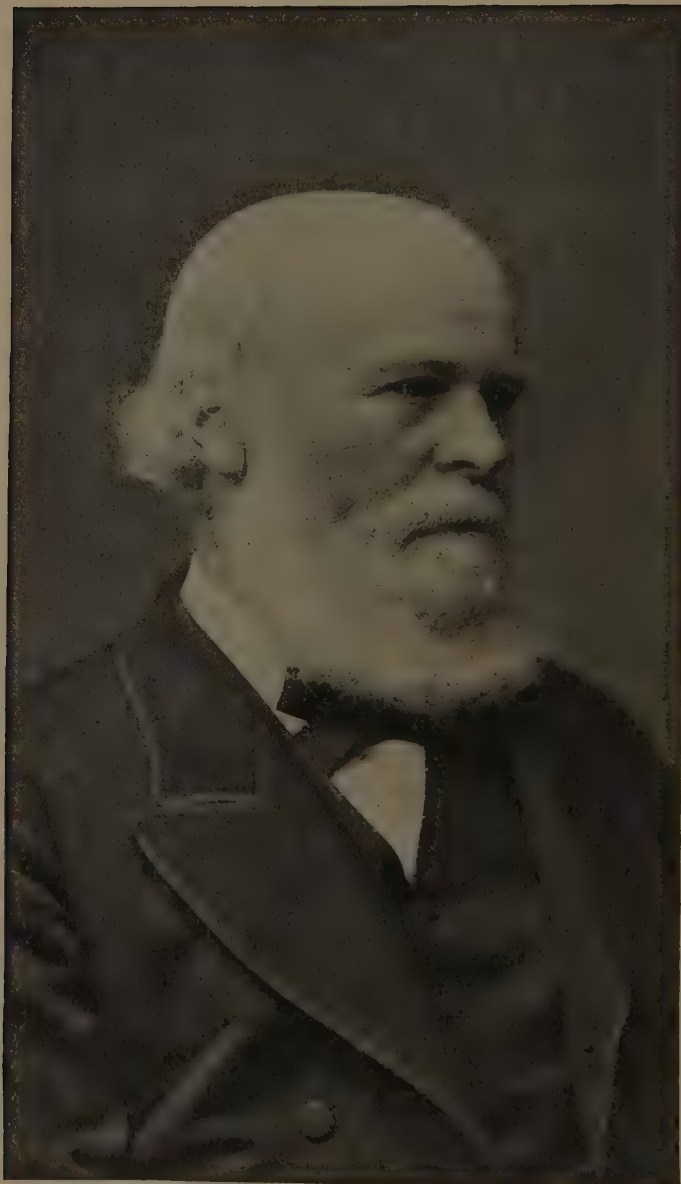
JOSEPH G. BUTLER, JR.

Youngstown, Ohio

In honoring me with a place on this program, the Committee evidently regarded half a century as long enough for any man to be actively engaged in the iron and steel industries. As a matter of fact my experience in them covers a period of sixty years, for I became shipping clerk and assistant manager at the iron rolling mill of James Ward & Company, Niles, Ohio, in 1857, after having spent three years as a clerk in the store connected with that enterprise, during which time I added to my accomplishments the musical art of speaking Welsh and also acquired the ambition to become an ironmaster.

The first use of iron in Egypt has been traced back to the ninth century B.C. and in China to about two thousand years B.C. The use of native iron in the form of meteorites traces back to remote antiquity. The weapons made from these were obtained, like flint implements, by chipping. It is interesting to remember that recent investigations have shown that the iron in many meteorites is a sort of natural steel. While the use of iron has thus extended over a period of more than three thousand years, most of the improvements in its manufacture and its use have occurred within my lifetime. Measured by man's conquest of the forces of nature, my life covers more than half of human history.

My sixty years of active business life cover the greatest progress the world has ever known. They have brought forth so many startling discoveries, so many striking inventions, so many achievements enriching and broadening human life, that merely to mention all of these would be a tedious task. Most of these were the work of American genius. They are the fruits of individual liberty and the



SIR LOWTHIAN BELL

An Eminent English Metallurgical Engineer and Writer
Author of "The Chemical Phenomena of Iron
Smelting." Father of Sir Hugh Bell

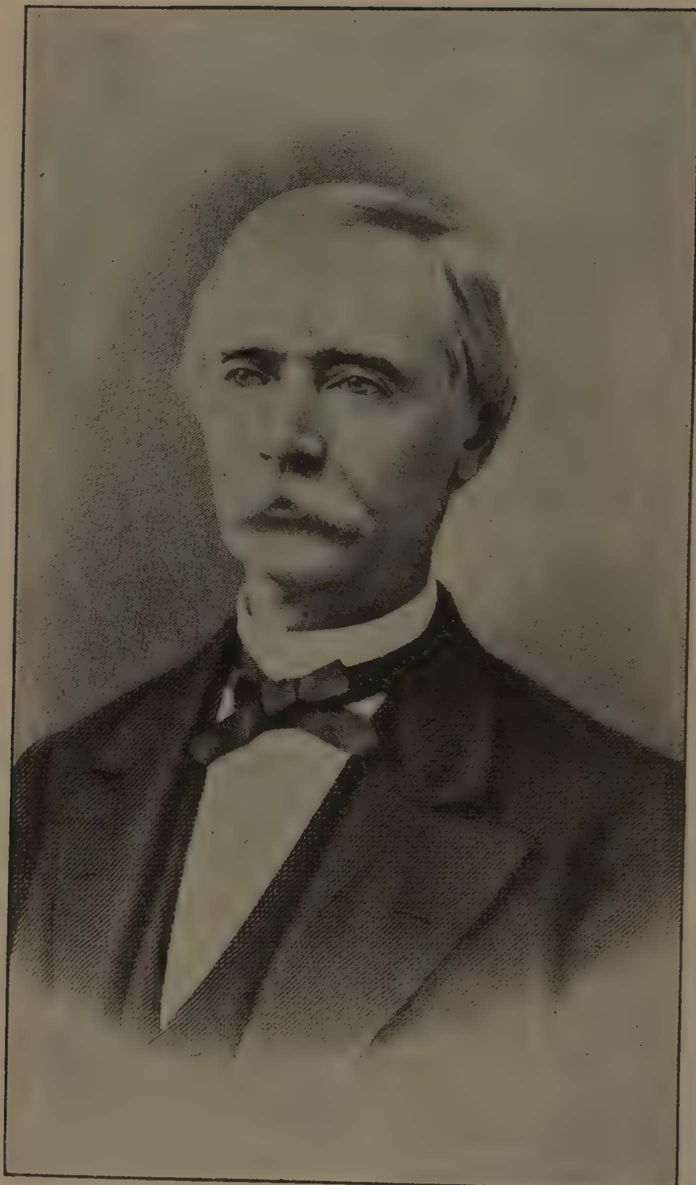
just reward for individual effort first known to the world after our forefathers had established freedom in enduring form upon this continent. The mere contemplation of this progress should serve to remind us of our obligations at this time, when civilization is turning the sharpest corner in its history and when the right of men to self-government and self-development is threatened as it has never been threatened before.

A Glimpse of Sixty Years Ago

Sixty years ago there was no such thing as the steel business in America. The trifling production of "blister" steel, amounting to a few thousand tons per year, was not worthy of that designation. But the iron business had already laid the foundations of its future greatness. And this in spite of the fact that we had then comparatively no ores, no efficient fuel, no adequate machinery and very little of the practical and scientific knowledge so widely diffused to-day.

When I entered the iron business, we made iron without coke—a task resembling that of the Hebrews who were compelled to make bricks without straw. We had what would now be considered no ore, for the chief supply was derived from an occasional pocket in the hills or gathered from swamps or the beds of creeks. We had no furnace tops, no blast stoves, no hot blast as we know it now, no metallurgists, and, in the light of the present experience, no markets. We knew nothing of the value of gas, natural or manufactured, a fuel indispensable in the manufacture of iron and steel in large quantities. But we did have grit and energy, the determination to do our best, and the same pride in doing things that we have now.

There were some compensations, of course. The payrolls were not so large and we were not troubled with a shortage of cars to move our product. I recently came across a statement issued by the superintendent of the Ward furnace, operated under lease at Youngstown, about the time of my entrance into the iron business. It reads as follows:



WILLIAM KELLY

Original Discoverer of the Pneumatic Process for Converting Iron into Steel

Youngstown, Ohio, August 25, 1853.

Messrs. James Ward & Company,

Gents.

Below you have the furnace proceeds for last week:

	Chgs.	Coal	Ore	Lime	Metal	Casting
Aug. 13	90	400	480	160	7½	
" 14	84	400	480	160	7	
" 15	87	400	480	160	7½	
" 16	87	400	480	160	6½	
" 17	84	400	480	160	7	
" 18	84	400	480	160	5½	3,300
" 19	81	400	480	160	6½	1,500
	597	118½	143	48	47½	4,800

Our next payroll will amount to something like $200. We ought to have at least $20 in cash. Yours, etc., etc.

James Cochran, *Superintendent.*

The payroll referred to was for one month. The cash was needed to give some of the men a little money for some special purpose. As a rule, they were paid in store goods. Among some other furnace records of those days I have seen an entry reading:

"Paid James Dobson six dollars to git married."

At some of the furnaces in that locality it was the custom to give the men a dollar in cash at Christmas and the Fourth of July. At other times they got along without any money. From all of which it will be seen that many things, among them getting married and running a blast furnace, were done with less capital than at the present time.

There was at that time no thought of making steel at the ordinary iron works. The equipment consisted of one or more small heating furnaces, one or two trains of rolls, perhaps a forge fire or two, a few puddling furnaces and occasionally some machinery for making cut nails. The product was usually either simply pig iron or merchant bars, a commodity which, by the way, has not changed its name in the whole 250 years since iron was first formed by forging into that shape.

The First Pneumatic Converter Used in the United States. Photographed on the Lawn of the Cambria Steel Company Offices in Johnstown, Pa., where it is Preserved as a Curiosity

The "Bessemer" Process Begins Age of Steel

The steel business in America was really born when the Bessemer process came into use here, which was not until about 1864. The idea of removing carbon and silicon from blast furnace iron in this way was undoubtedly first conceived by an American, although he failed to develop the machinery for its use and, as a consequence, reaped very little benefit from it. When William Kelly, who first decarburized iron by means of an air blast in a furnace he had erected for that purpose at Eddyville, Ky., about 1850, came to file his claim for a patent in 1856 he found that Henry Bessemer had filed similar claims and been granted patents a few days previously. Kelly had worked for years on his scheme, which was identical in principle, but he had not yet made it a commercial success and did not attempt to make steel in that manner. Nevertheless, the fact that he was the first to use the pneumatic process was not disputed and he was granted an interference as against the Bessemer patent.

I recall distinctly a visit made by this man to Niles about 1854, while I was a member of the Ward family, being employed in the Ward store. He came there to enlist the interest of James Ward, then regarded as an authority on the iron question, in behalf of his experiments, and was a guest at the Ward table on several occasions. How far he succeeded in his errand may be judged by the fact that Mr. Ward said after he left that he was crazy.

Other Important Discoveries and Inventions

The invention of the Bessemer process, or rather its perfection and development, is generally regarded as the longest single step in the march of progress that has brought the iron and steel industries to their present stage, but there are other discoveries that seem to me even more important. We cannot make steel without iron, and therefore of even more moment than this invention were such things as the discovery of the Lake Superior ore ranges, the invention of the furnace top, the use of coke and ts economical

SIR HENRY BESSEMER

For Whom the Bessemer Steel Process was Named

manufacture, the development of high blast temperatures and, especially in view of its recent rapid adoption, the development of the Siemens-Martin open-hearth furnace.

All of the various steps in these improvements have been made during the time in which I was greatly interested in them, and it has been my pleasure and privilege to follow them closely and to know something of the trials and disappointments undergone by men who conceived and brought them to perfection, or rather to their present state—for it is entirely probable that future generations will continue the work with the same zest and at least part of the success that has attended it so far.

As has been stated, I met Mr. Kelly when he was trying to make his great discovery a practical success. I saw him on a number of occasions later, when he was working to unravel the skein of litigation that tied up the Bessemer process and prevented its adoption in this country until ten years after it was patented here. I can recall the announcement in the technical journals of that day of the discovery by Robert Mushet, a Scotchman, that spiegeleisen would recarburize iron blown in a converter and thus produce steel. We did not know of this in America for some time after Mushet's patents were granted in England, which was in the latter part of 1856. Up to that time Kelly did not suspect that he had found a new way to make steel and had urged his process on iron manufacturers only as a cheap and rapid method of purifying iron for rolling mills, claiming that it would take the place of puddling—something, by the way, it has never done.

Development of the Hot Blast

Likewise I was privileged to watch every step in the development of the hot blast. At the Ward furnace at Niles, and in other furnaces in the Valley, the blast was heated by passing it through cast iron pipes. These pipes lasted but a short time. Their renewal and replacement kept the local foundries busy and interfered seriously with continuous operation. We had what we called a hot blast,

Iron Furnace Erected at Farrandsville, Pa., in 1830

but it was really only warm in comparison with modern practice. The furnacemen tested its temperature with lead and zinc, strips of which were inserted at the point where it entered the furnace. If the blast melted lead it was not quite hot enough, and if it melted zinc it was too hot, so we believed, and would burn the iron. Between the melting point of lead and zinc, as we now know, there is a very considerable difference, so that our wind varied about as much in temperature as it did in pressure. If you reflect that the blast in those days was blown usually by an engine that had been worn out on a Mississippi River steamboat, and that when the engine broke down it was the usual thing for the men about a furnace to operate the walking beam by "man power," you will have some light on the strength and steadiness of the hot blast of that day.

It was about 1868 that the Player hot blast stove was brought from England to this country. It was a decided improvement. This stove introduced an innovation in being located on the ground instead of at the tunnel-head. The first stove to employ the regenerative principle was the Whitwell stove. This was lined with fire-brick, also a new idea. Both it and the Player stoves immediately increased the output of furnaces and made larger stacks possible, and reduced the quantity of fuel used per ton of iron made, but it was many years before they supplanted the old Thomas stoves at many American furnaces.

The Use of Furnace Gas Introduced Here by Germans

The use of furnace gas for heating the blast in this country we owe to the Germans, the first effort to bring these gases down and burn them under stoves and boilers in America having been made about 1850 by C. E. Detmold, a German engineer residing in New York. The new plan cost a good deal of money and for that reason was slowly adopted. We did not get to it in Ohio for some years after it was used in the east. I recall very distinctly the first furnace top installed at Youngstown. It was thought highly

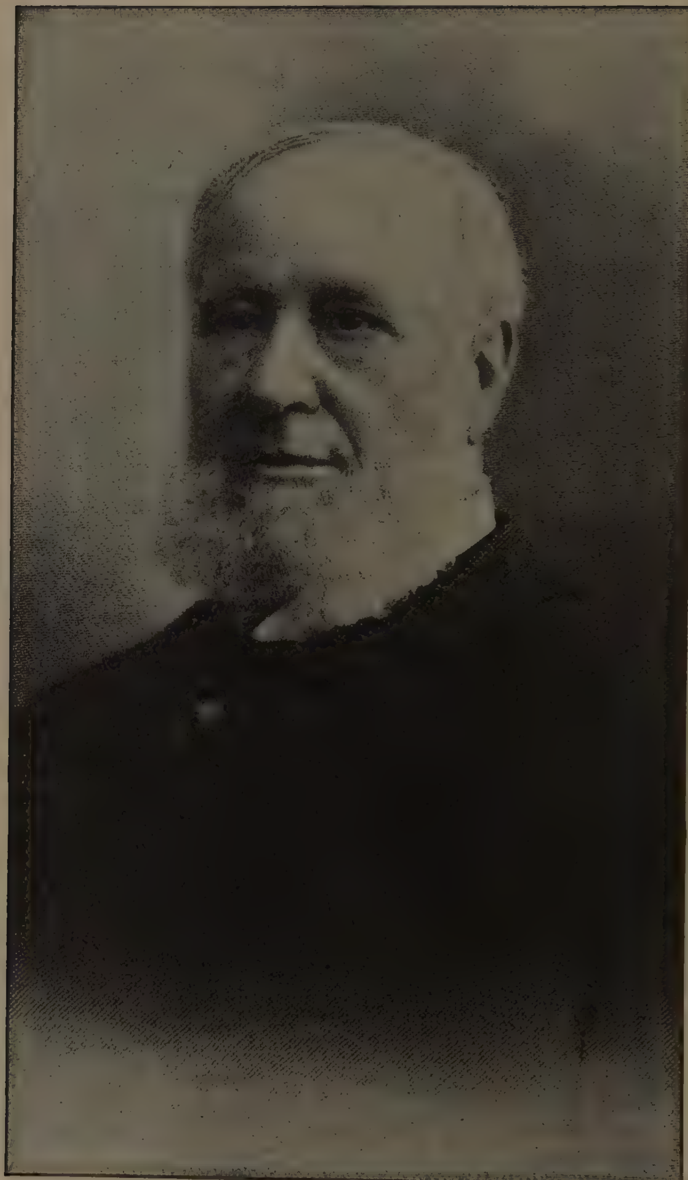
Old Furnace at Bailey's, in Pennsylvania

dangerous by the workmen, and there was at first some difficulty in getting them to work around the stack.

With the use of better stoves and the introduction of more powerful blowing engines, furnaces began to grow in size and more attention was paid to their lines. It was realized that much improvement could be made in the output, and progress in this direction was rapid. By 1875 it was known that blast furnaces could be operated successfully up to 80 feet in height, and, with coke for fuel and proper equipment for blowing and heating the blast, could be made to yield much larger product than had been expected up to that time. But it was not until about 1880 that one of these larger furnaces reached an output much above 100 tons per day. This was the Isabella, located at Etna, near Pittsburg. During three years (1881, 1882 and 1883), this furnace produced an average of 1,090 tons per week—the best ever done by a blast furnace up to that time in this or any other country.

Old Stacks Would Seem Picturesque

To those who have had experience only with the present day blast furnace and modern furnace practice, it is impossible to portray the conditions surrounding our industry at the time when I first became interested in it. The old stack of those days, with its equipment, would be picturesque in the extreme if it could be set up in the vicinity of a modern steel works. The stack was usually about 35 feet in height and built of masonry, lined on the inside with a poor quality of fire-brick. It was square in section, on the outside, the bottom being about 24 feet each way and the top somewhat smaller, this depending on the ideas of the man who designed it. The stack was usually located against a bluff, the double purpose being to make construction cheaper by using the hill to reinforce one side and to enable a patient mule to perform the functions of a skip hoist by dragging the ore to the top of the hill. A short bridge connected the stockhouse with the top and the material charged was wheeled from this point and dumped in at the open top.



BENJAMIN FRANKLIN JONES

Founder of The Jones & Laughlin Steel Company. A Pioneer in the Development of Iron and Steel Manufacture in Pittsburgh

Only one or two tuyeres were used, and these were often on the same side of the stack, next to the blowing engine. In front was the sand bed, into which the iron was run, and to one side the space reserved for roasting the ores. No water-cooling devices were used except at the tuyeres and the opening in front. It was a very small proposition compared with what we are used to at this time, but was, nevertheless, a source of general public interest and regarded with considerable awe by the uninitiated.

I can recall the first furnace in our district whose builders had nerve to locate it away from a hill. They used a hoisting device in which a tank filled with water raised the platform on which two wheelbarrows loaded with ore had been placed. When the barrows were dumped they were wheeled back on the platform, the water was let out of the tank at the other end of the rope, and they came down to be refilled.

The blowing engines were of the crudest type and had but little power. There was then no method of gauging the pressure accurately and this was one of the cares of the furnace boss. He was expected also to know when the furnace was ready to cast, the proper color of the iron, and a great many other things. As a rule he did know these things better than might be expected, and these old furnaces made good iron even if they did not make much of it.

Even this type of furnace was a great improvement over those in use in that locality forty years earlier, for they used the "trompe" or water blast, which was, you may be sure, somewhat removed from the Gayley Dry Blast. This was a contrivance by which a waterfall was made to carry air into a box, compressing it in the top, from which it was carried to the furnace through a small pipe.

Early Efforts to Solve the Transportation Problem

It is a curious circumstance that the first furnace erected by the Carnegie Steel Company was one torn down at Escanaba and taken to Pittsburgh. It had been erected in Michigan to be near the ore fields, but its owners found that

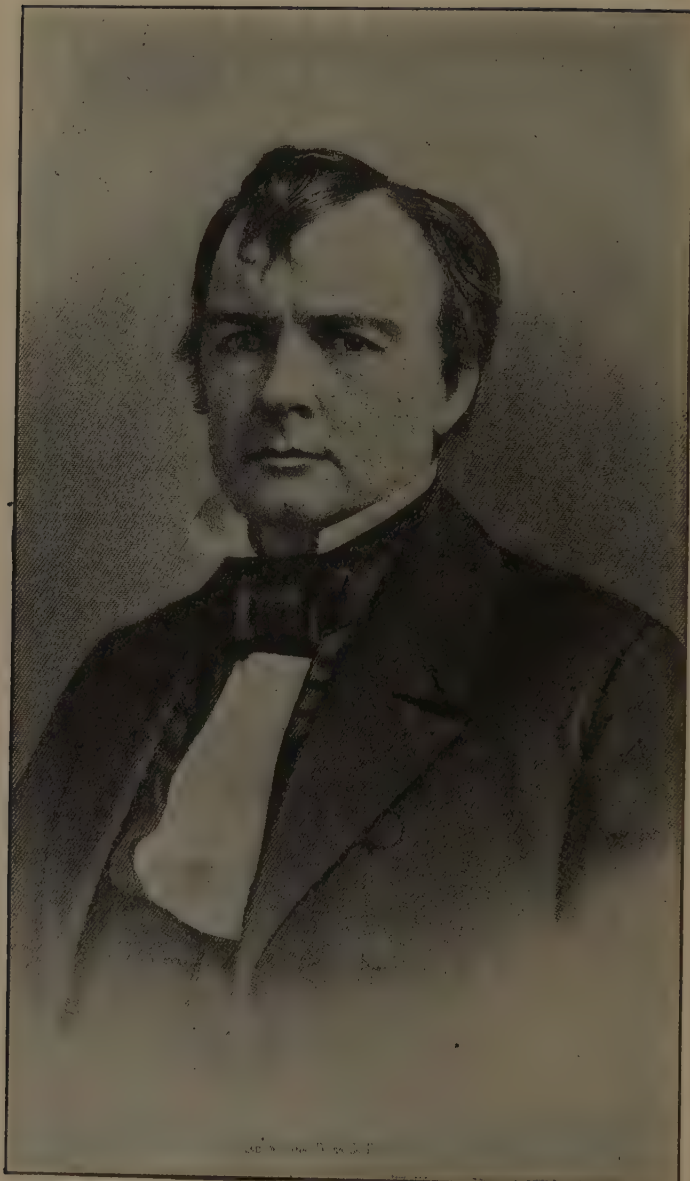
An Abandoned Iron Furnace. The Tree Growing Out of One Side Best Indicates the Age of the Stack. Eastern Pennsylvania

the problems of transportation could not be solved in that way alone.

Scattered all over the Eastern States can be found the ruins of once ambitious efforts to make iron cheaply by locating furnaces close to the ore. Some of the most pathetic failures, however, were furnaces placed, as their builders believed, close to both ore and fuel, and even to transportation. In the Juniata Valley and the Allegheny Mountains are many of these monuments to the realization that the problems of transportation are of great importance in the iron industry. These old stacks, built to defy the ravages of time, were placed where ore had been found and where wood was abundant for the making of charcoal. Most of them were built after the construction of the Pennsylvania Canal and the Old Portage Railroad, both huge enterprises for their day. But the canal has disappeared, the famous old railroad is nothing but a memory, and these hollow structures of stone remain as mute witnesses of the fallibility of human calculations and the certainty of that change which is the seed of all progress and which is continually building on the ruins of the best efforts of men better things than those of which they dream. Huge trees may be seen on the tops of some of these old furnaces and around their bases the forest leaves have buried fragments of pig iron, which, precious as it was, had to be left behind in the rapid march of progress.

Special Coal Caused Valley Development

When I first became interested in the furnace business, all the stacks in the Mahoning Valley, as well as those in Hocking Valley, at Canal Dover and at several other points in Ohio, were using raw coal. It was to a rich deposit of black-band ore found underneath the coal at Mineral Ridge, near Niles, and the equally important discovery at Brier Hill, in Youngstown, of coal making a fairly good fuel in its raw state, an almost natural coke, that the development of the iron industry in the Mahoning Valley was due. This coal, very similar to the Scotch coal afterwards found in other



HON. DAVID TOD

Pioneer in the Manufacture of Iron and Mining of Coal in the Mahoning Valley. Pioneer Railroad Builder. Civil War Governor of Ohio

parts of Ohio, was rich in carbon and low in ash, and in the hands of those who understood it made a better blast furnace fuel than had yet been found at its low cost. For years it was mined close to the stacks and hauled by mules. All of the ore—usually a mixture of black-band, kidney and bog ores—had to be roasted before charging. This was done with wood and coal in great heaps near the furnaces. The output of the four furnaces then in operation in that district was certainly not more than two hundred tons per week. From this has grown a business employing fifty blast furnaces and producing, during 1916, 6,923,938 tons of pig iron. From the few small rolling mill plants then in that neighborhood have been evolved forty-six modern rolling mills, rolling more than four million tons of steel per year.

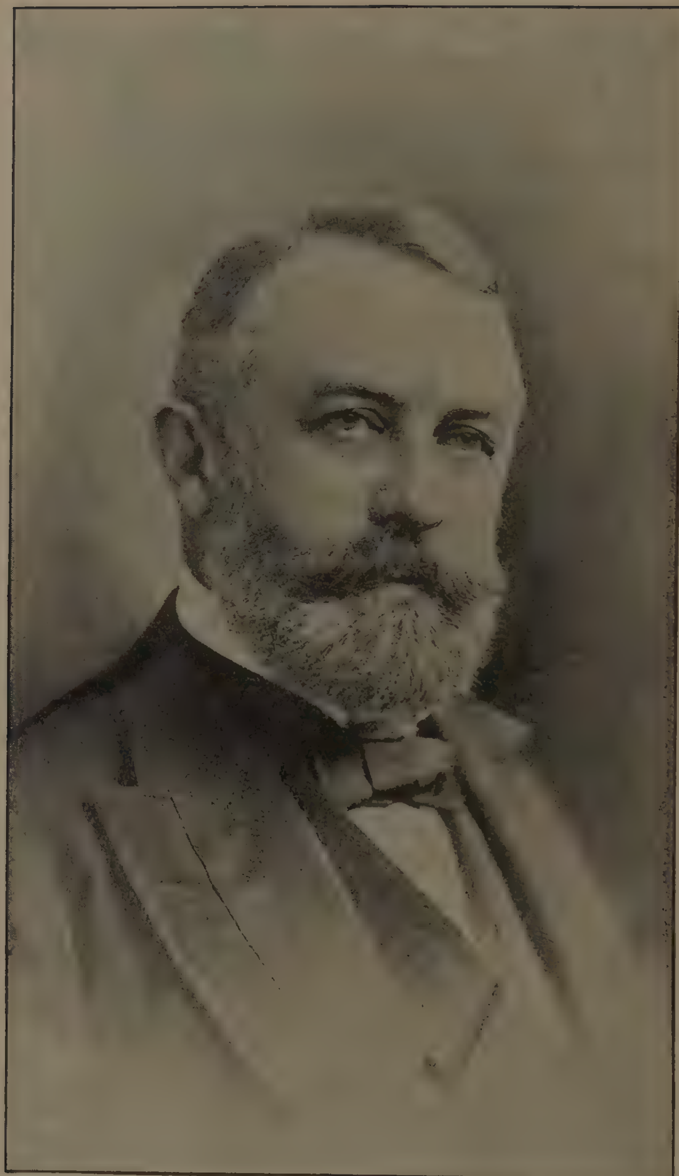
Owing to the advantage of this natural fuel, known as "Brier Hill" coal, we did not begin the use of coke in furnaces at Youngstown until 1869, at which time the coal began to grow scarce. An Englishman employed about one of the furnaces had some years previously made coke by covering coal in a heap, and this was used on occasion when a furnace went cold; but the raw fuel, the coal, was the main dependence until about the date mentioned, when we began to use beehive coke.

Development of Coke as Furnace Fuel

About 1860 coke was regularly used as fuel in the Clinton furnace at Pittsburgh. Within a few years it proved so efficient that all other fuels were practically eliminated except for making special grades of iron.

The employment of coke as a blast furnace fuel was an advance of such importance that it is worth while to refer to it somewhat more comprehensively. It was known in Germany and England long before its use anywhere in America, where charcoal was at first relatively low in cost.

The date and place where coke was first used in this country are not entirely certain, but it was possibly tried in several places at the beginning of the last century. A paragraph in a history of Fayette County, Pa., refers to



HENRY CLAY FRICK

Whose Strength of Purpose, Integrity and Ability Have Been Felt Throughout America's Great Industries

the use of coke in the Allegheny furnace, Blair County, in 1811. William Firmstone used it for a short time in a furnace in Huntingdon County, Pa., in 1835, but abandoned it later. There seems to be no doubt that he succeeded in making good gray iron with it at the date mentioned, but why he did not continue has never been recorded. In 1856 there were twenty-one furnaces in Pennsylvania and three in Maryland using coke, but, so far as is known, none west of those states. The census of 1850 enumerates four furnaces as burning coke, and by 1860 twenty-one reported its use. In the next ten years the census people found only five more plants using coke, but it is probable that there were many who did not report its use at that time. At any rate, by 1880, the census reports enumerated 149 stacks blowing on that fuel.

From that time on, coke rapidly supplanted charcoal and all other fuels, including anthracite coal. It is now used almost exclusively. Out of 465 blast furnaces now in operation or building in this country, only forty use charcoal, the others being fired with coke, or, in a few instances, with coke and coal mixed. The charcoal furnaces are chiefly small and of antiquated type, their output for 1916 being only 372,411 tons of iron as compared with 39,062,386 tons produced in coke or in coal-and-coke driven stacks. No new charcoal furnaces were reported building in 1916, but 17 coke furnaces, with an annual capacity of 3,151,000 tons, were under construction at the close of that year.

Early Prices of Coke and Ore

It was my privilege to make the first contract for coke entered into by Mr. H. C. Frick, when he began the coke business on his own account. I would be ashamed to tell you the price, and I think he would also. I bought the first coke used in the Mahoning Valley for a furnace at Girard, then under my management. The exact date has escaped my memory, but it was in the late 60's. This coke was used as a mixture with Brier Hill coal, and some coal was still used as a mixture until twenty years later when

SAMUEL M. FELTON

A Pioneer in the Manufacture of Steel. One of the Founders of The Pennsylvania Steel Company

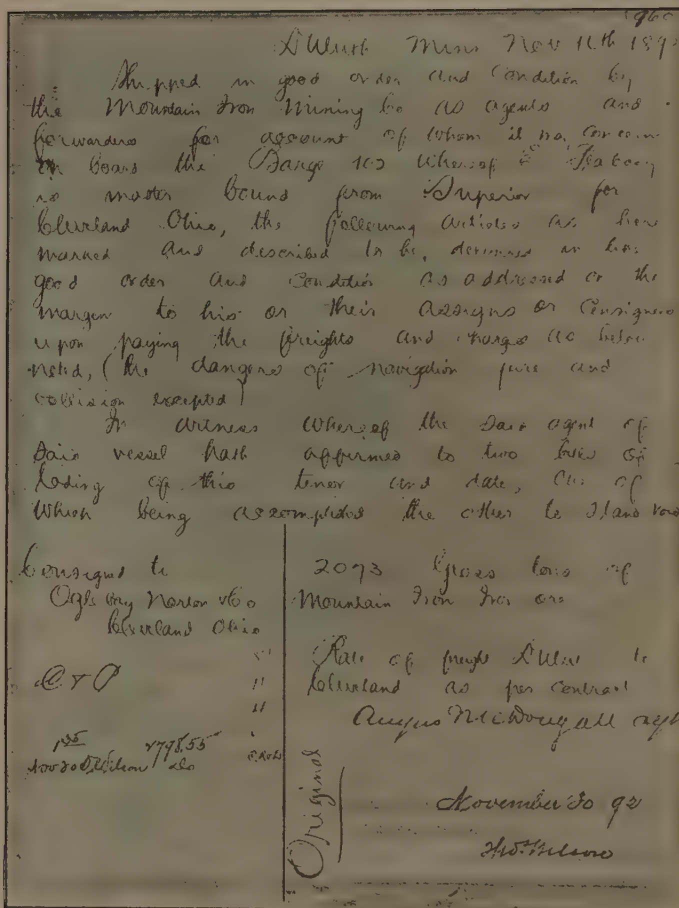
we could no longer obtain it in satisfactory quantities. The mixture made what we thought then was a very satisfactory and economical fuel, the coal adding to the surplus gas production.

I have bought many thousands of tons of good beehive coke at eighty-five cents per ton. The average selling price of the entire output of the country in 1880 was $1.99 per ton at ovens. There were then 12,372 beehive ovens in operation, and the production was 3,338,300 tons. During 1916, according to the estimates at hand—the exact figures not being available—the country's entire production of coke was 54,325,000 tons, and of this 35.35 per cent. was made in by-product ovens. Some coke was sold in 1917 as high as $15 per ton—a surely "war price."

Unfortunately I am not able to give the cost of ore at the furnaces of early days. The records then kept were imperfect in this respect and the dollar did not mean the same thing as it does now. But it was very high in spite of the exceedingly low price of other commodities, and must have varied greatly at different furnaces, depending on whether it was mined from rich deposits or from those where it was poor in quality and limited in quantity.

Development of the By-Product Coke Industry

Hardly less important for the country than the addition to furnace output resulting from the use of coke is the rapid development of the by-product industry. It has grown from 5.41 per cent. in 1901 to 35.35 per cent. in 1916. No other single development has done so much to conserve the natural resources of America and none has more effectively indicated the energy, wisdom and public-spirit of the men at the head of our iron and steel plants. The erection of by-product plants involves huge expenditures, but they make large profits and save for future generations incalculable natural wealth. It is safe to predict that the wasteful beehive oven will soon take its place in the limbo of great mistakes, among the dust of ignorance, with many other things that were once hailed as great discoveries and thought to be the limit of human knowledge.


Duluth Minn Nov 11th 1892

Shipped in good order and condition by the Mountain Iron Mining Co as agents and forwarders for account of whom it may concern on board the Barge 102 whereof [illegible] Tabor is master bound from Superior for Cleveland Ohio, the following articles as here marked and described to be, delivered in like good order and condition as addressed on the margin to his or their assigns or consignees upon paying the freights and charges as below noted, (the dangers of navigation fire and collision excepted)

In witness whereof the said agent of said vessel hath affirmed to two bills of lading of this tenor and date, one of which being accomplished the other to stand void

Consigned to
Oglebay Norton & Co
Cleveland Ohio

O N C

1.35 778.55
Nov 30 D. Wilson do

2073 Gross tons of
Mountain Iron Iron ore

Rate of freight Duluth to
Cleveland as per contract

Angus McDougall agt

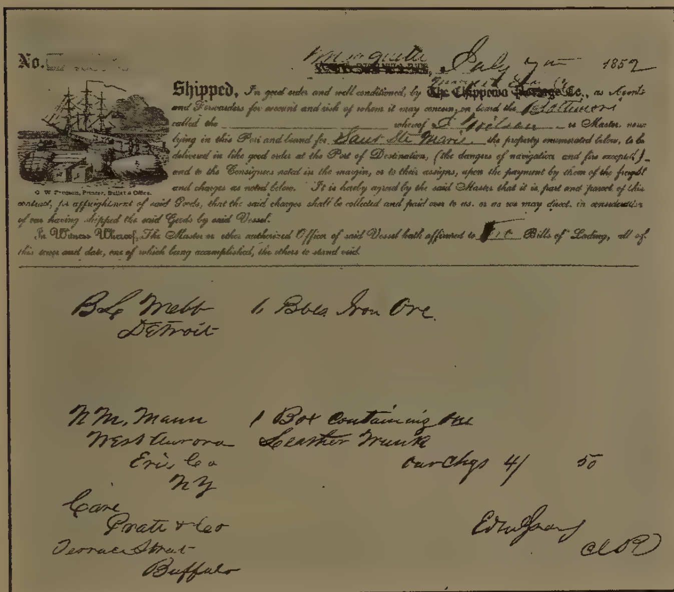
Original

November 30 92

H. D. Wilson

Reproduction Bill of Lading First Shipment of Mesaba Ore.
Loaned by Oglebay, Norton & Co.

Comprehensive and valuable papers on this subject were read at meetings of this Institute in 1913 by Carl A. Meissner and in 1914 by William H. Blauvelt, and may be found in our Institute Year Books for those years, so I shall not discuss this subject further now.



No.

Marquette, July 7th 1852

Shipped, In good order and well conditioned, by The Chippewa Portage Co., as Agents and Forwarders for account and risk of whom it may concern, on board the called the ______ whereof ______ is Master, now lying in this Port and bound for Sault Ste Marie the property enumerated below, to be delivered in like good order at the Port of Destination, (the dangers of navigation and fire excepted) and to the Consignees noted in the margin, or to their assigns, upon the payment by them of the freight and charges as noted below. It is hereby agreed by the said Master that it is part and parcel of this contract, for affreightment of said Goods, that the said charges shall be collected and paid over to us, or as we may direct, in consideration of our having shipped the said Goods by said Vessel.

In Witness Whereof, The Master or other authorized Officer of said Vessel hath affirmed to ______ Bills of Lading, all of this tenor and date, one of which being accomplished, the others to stand void.

G. W. Pattison, Printer, Bulletin Office.

B. L. Webb 6 Bbls Iron Ore
Detroit

W. M. Mann 1 Box containing one
West Aurora Leather Trunk
Erie Co Our Chgs 4/ 50
N Y
Care
Pratt & Co
Terrace Street
Buffalo

Reproduction of Bill of Lading First Shipment of Lake Superior Ore. Loaned by Oglebay, Norton & Co.

Important New Sources of Ore Supply

The development of the Lake Superior ore deposits has exercised on the iron and steel industries of the world an influence more far-reaching than any other incident in their history. Previous to that time furnaces and iron works had been located in many places where ore and fuel could be found. But the time had come when such resources were inadequate to meet the growing needs of the country. Perhaps it would be more accurate to say that the time had come when the further progress of civilization demanded iron ore in quantities and at a cost hitherto

A Furnace Explosion at Sharpsville, Pa., Caused by Mesaba Ore in the Early Days of Its Use

undreamed of. There is no question that, from the time of the discovery of the Mesaba Range, civilization and progress received a tremendous impulse from the cheaper iron and steel it made possible. From this time it became evident that the production of these commodities had to be on an enormous scale, and that the day of the small furnace was at an end. It became evident, also, that henceforth the industries must be confined to those localities where ore and fuel could be assembled in vast tonnages at low cost and markets reached with the greatest facility. The first effect of this discovery was to practically limit the production of iron and steel in large tonnages to regions most accessible to great ore and fuel deposits. The Pittsburg and Youngstown districts had no rival in this respect, except, perhaps, the Atlantic coast district, where the rich ores of Cuba and South America were available at equal distance from the Connellsville coke field. Even this district is now suffering from the accidental dislocation of ocean freight service and is glad to get ores from Lake Superior, which have no equal in low cost and purity.

The honor of discovering the ore deposits near Lake Superior is variously claimed. Some writers credit it to government engineers who noticed a variation of the magnetic needle and investigated the cause. Others state that the Indians had found the ores and reported large masses of "iron stone" in that locality. I am inclined to think the honor belongs to Philo M. Everett, who in 1845 located the Marquette Range in company with Indian guides.

The various ranges were opened for shipment of ore in the following order:

Marquette	1850
Menominee	1870
Gogebic	1884
Vermilion	1884
Mesaba	1892
Michipicoten	1900
Baraboo	1904
Cuyuna	1911

Old Spearman Furnace at Sharpsville, Pa., now Shenango Valley Furnace Co.

Westerman Iron Co.'s Rolling Mills, Sharon, Pa., about 1895

BIG JIM KENNEDY

An Old-time Furnaceman

The first regular shipments in cargo down the lakes began somewhat later than the dates mentioned for all these ranges. That from the Marquette was in 1856, the opening of the Sault Ste. Marie Canal in that year having made possible cargoes large for that day, although they would seem insignificant at this time. The total shipments by water from this region in 1856 were only 7,000 tons, about half enough to make a cargo for a modern ore boat. This ore was valued at $28,000. In 1856 first-class "specular" or "hard" ore from the Marquette Range brought $7 per ton on the docks at Cleveland.

Up to 1908, all the ranges in the Lake Superior Region had produced a total of 407,060,116 tons of ore. In 1912 their output had increased to 48,221,546 tons for that year alone, and in 1916 it reached the grand total of 66,658,466 tons—or 11,000,000 tons more than the entire production of the United States in 1915, according to the figures of the United States Geological Survey.

In 1916 the Mesaba Range alone produced 42,525,612 tons, or almost 64 per cent. of the whole region, achieving a record as the greatest source of iron ore on the globe. The Mesaba Range has led in production since 1895, and its development has revolutionized the iron and steel industries of America. Because the ore on this range can be mined with great economy and because of its close proximity to the lakes, it can furnish ore at a lower cost per ton of iron than any other part of the world where there are furnaces to smelt it. Equally rich and accessible deposits may exist in India and South America, but it must be remembered that the tropics are not suited to the manufacture of iron, and it is not likely that anything equal to this range will be found within the temperate zones. Because of the conditions on the Mesaba Range we have learned to mine ore by stripping, even at a depth of 300 feet, and this of itself has been a long step toward economy in the cost of production.

Improvements in Mining and Transportation

Following the development of the Mesaba Range came the astounding improvements in mining and transporta-

CAPT. EBER B. WARD

Chief Owner of the Plant at Wyandotte, Mich., and Responsible for the Construction of the First Successful Bessemer Converter in America

tion of ore which, together with the tremendous supply of the Lake Superior region, have had much to do with the phenomenal growth of our iron and steel industries.

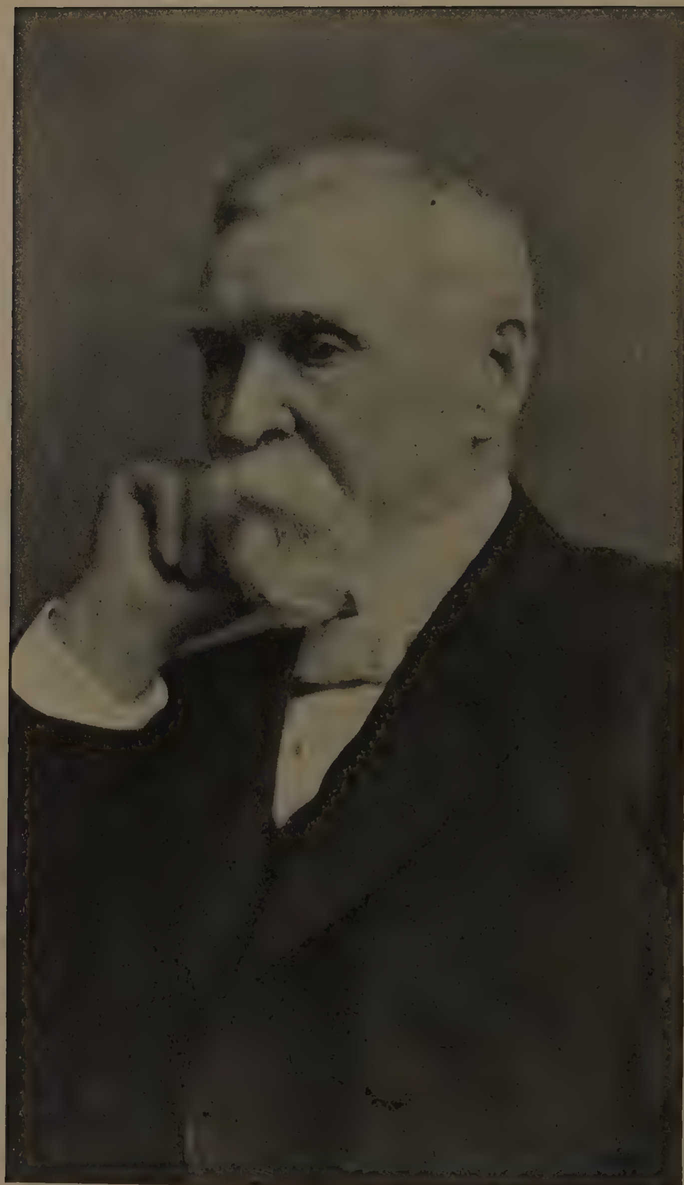
When we began to use Lake Superior ores the ordinary cargo of a lake boat was 500 tons. It required several days to load and unload this cargo at every point where it had to be handled—four in all. The ore cars then in use carried only ten tons. When their capacity was increased to twenty-five tons and boats were built that would carry 1,000 tons, we thought our problems were solved. Now we have vessels loading as high as 12,000 tons at the upper ports in two or three hours with one or two men on the dock, and unloading their cargo directly into fifty-ton cars in about the same time and with practically no manual labor.

In the old days men with shovels loaded the ore at the mines into small cars, from which it was transferred to railroad cars. They handled it again the same way four times before it reached the furnace, for even the hopper car had not then been invented. Aside from being the most laborious task to which a human back was ever bent, this was extremely costly and slow beyond your belief. Now we handle this vast tonnage entirely by machinery. Steam shovels mine the ore; it flows by gravity into great vessels; huge unloaders transfer it to railroad cars, and car dumpers empty it under ore bridges—all the work being done by power and at a speed little short of miraculous. These things were all unknown a half-century ago. They are the product of the tireless brains and the unflagging energy of the men who have built our industries to their present colossal proportions.

The story of the development of transportation on the Great Lakes was admirably told at our May meeting in 1913 by Harry Coulby, whose paper appears in our Institute Year Book for that year.

Development of Blast Furnaces

The improvements in blast furnace construction and practice referred to in previous paragraphs had much of their inspiration from these changes in the method of hand-



JOHN FRITZ

Noted Inventor; Practical Worker in Iron and Steel of International Reputation

ling ores. With them came changes in size, lines and equipment. These changes were most marked during the period between 1860 and 1890. In 1850 there were few furnaces in the country that could produce 150 tons of iron in a week, and the average did not reach that figure until about 1865. In 1890 a furnace at the Edgar Thomson Works, built under the design of Julian Kennedy and operated under the direction of Capt. Bill Jones, startled the world by yielding 502 tons of iron in one day and 2,462 tons in one week. That was then believed to be the limit of production, but it is now quite usual for stacks to exceed this figure, and there are a few producing 600 tons per day.

In 1860 the total output of pig iron in the United States was 821,223 tons. In 1890 it had risen to 9,202,703 tons. During 1916 there were made in America 39,434,797 tons of pig iron of all grades.

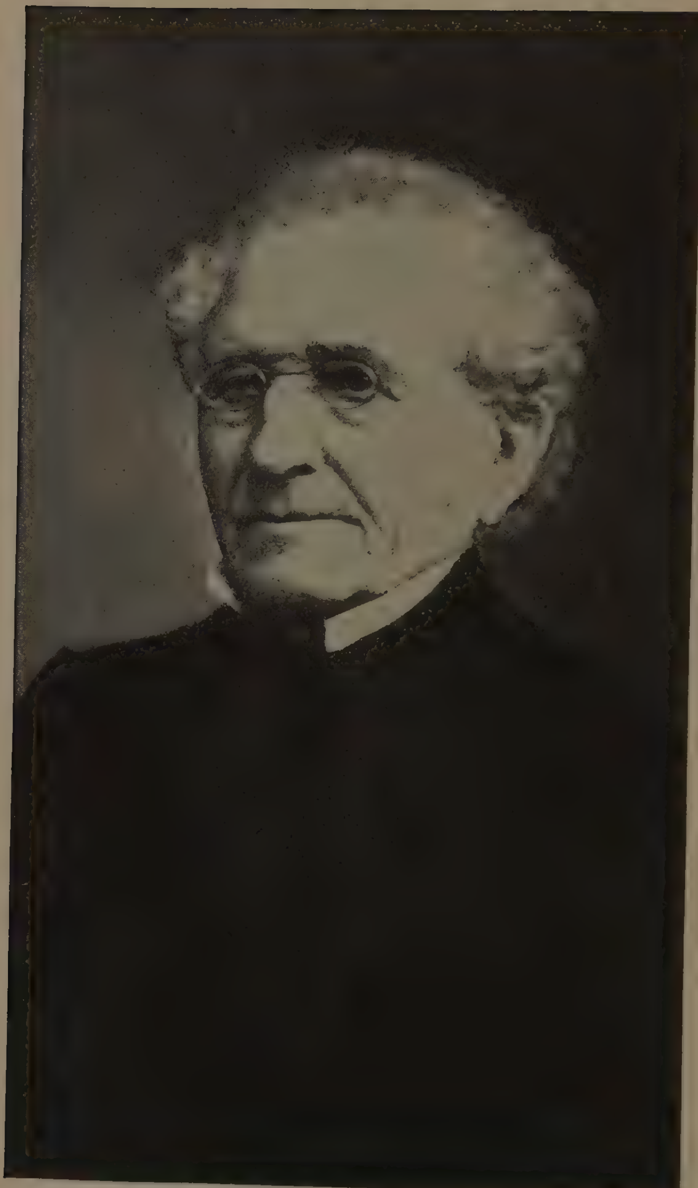
The Iron and Steel Industry in the South

The remarkable growth of iron and steel manufacture in the South deserves almost a separate paper, but I understand it must only be a feature of my address.

The subject has been treated by many writers: the late James M. Swank, E. A. Smith, Miss Armes of Birmingham, and others. A paper read by James Bowron at the long-to-be-remembered meeting of the Institute in Birmingham, Ala., in 1914, should be read by everyone desiring to be thoroughly familiar with the Southern industry.

It is somewhat difficult to differentiate the south metallurgically. Mason & Dixon's line and all east of the Mississippi, except Florida, Mississippi and Louisiana, would probably include it.

Before the civil war no iron was made in the south with mineral fuel, but charcoal furnaces were quite common, as well as forges. As early as 1725 a furnace was built in Virginia on property owned by Lawrence Washington, brother of George Washington. The ruins of this furnace can still be seen. Small furnaces were in operation through the eighteenth and nineteenth centuries. Ship-plates of ex-



DAVID THOMAS

Inventor of the Thomas Hot Blast. Made the First Pig Iron with Anthracite Coal as Fuel

ceptionally good quality were made in the south before the war from charcoal blooms. The war practically stopped all the manufacture of material. Some of the plants were taken over by the Federal Government. Dating from the close of the civil war a great deal of capital was invested in Alabama and Georgia, principally English money.

Sir Lowthian Bell, a world-wide authority, visited this country with the British Iron and Steel Institute in 1890, and he said: "I will not say that Birmingham will furnish the world with iron, but I will say that she will eventually dictate to the world what the price of iron shall be." Incidentally I might add that it was my good fortune to know Sir Lowthian Bell, he having visited the United States on several occasions. His work, "Chemical Phenomena of Iron Smelting," is a classic and should be in the library of every iron manufacturer today.

To go into details of the developments through the south would occupy too much time. I think it safe to say, however, that the first real prosperity in the southern industry as a whole, dates from the acquisition of the property of the Tennessee Coal, Iron and Railroad Company by the United States Steel Corporation. It is believed by many in position to know that the purchase of this property at the time when it was acquired saved the nation from a most disastrous panic, or rather minimized the panic then in existence and eventually stopped it.

The Roane Iron Co. built blast furnaces at Rockwood, Tenn., fully a half century ago and they are still in successful operation. This same company undertook the manufacture of Bessemer steel rails at Chattanooga but the experiment was a failure. Now that the open-hearth rails have practically supplanted Bessemer steel rails, it is interesting to report that the Tennessee Coal, Iron and Railroad Company is one of the largest manufacturers of open-hearth steel rails in the United States.

The southern ore supply is practically without limit. Its iron contents are much lower than the Lake Superior ores, but the south has the advantage of the coal, ore and flux being all in close proximity.

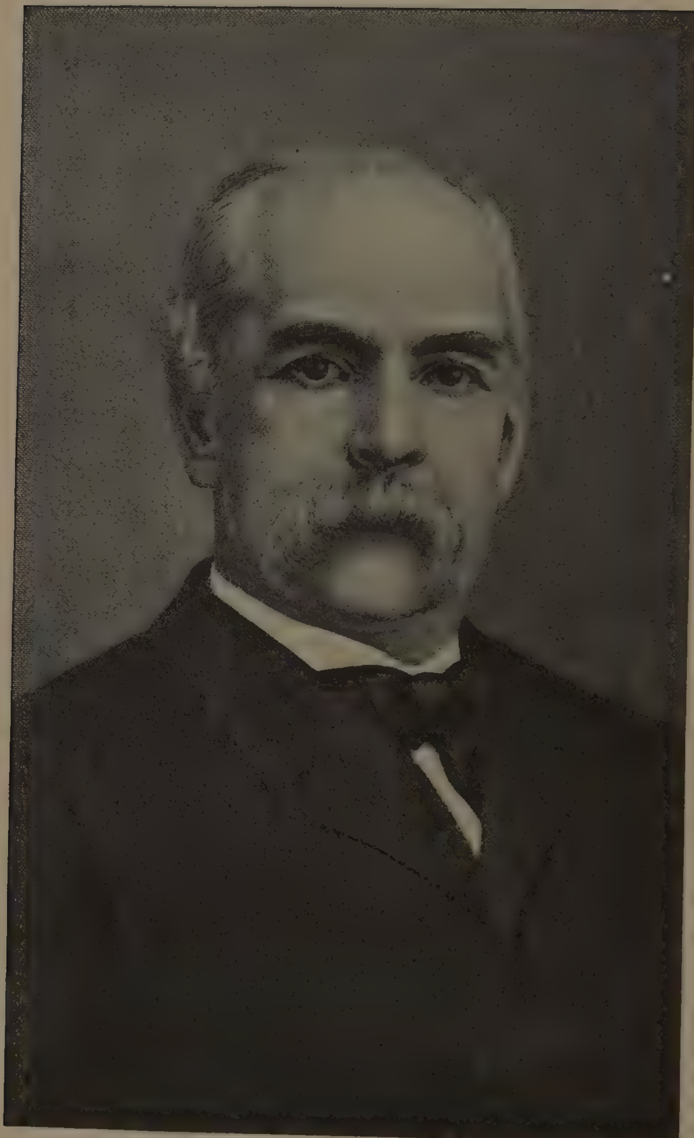
WM. R. JONES (Capt. Bill Jones)
A Genius in Blast Furnace Practice. A Martyr to His Zeal

It is interesting to note that General Sherman, whose well-known characterization of war has become fixed and emphasized in the minds of the whole world, built a rolling mill at Chattanooga in 1864 for the United States government. This was used for rolling iron rails. Steel rails were then unknown. Iron rails from all the roads in the south which were accessible to the northern armies were brought to this mill, cut up and made into piles with new puddle iron for heads and rerolled into sections of from fifty to sixty-five pounds per yard. The manufacture of iron and open-hearth steel, and more particularly pig iron, is today in a very prosperous condition throughout the south, and I predict for the industries in that section increased prosperity.

An additional word about Captain "Bill" Jones will not be out of place in this connection, since he was, in a sense, the south's most notable contribution to the progress of American iron and steel industries. Captain Jones was for a time one of the most important practical men in the Carnegie plants. He was an inventor, and a manager of great ability. When the civil war broke out he was employed at Chattanooga, Tenn., but on account of his Union sympathies felt obliged to leave that section. He worked his way to Johnstown, going up the river on a steamboat. He was killed in a gas explosion at one of the Carnegie furnaces. Had it not been for his untimely death he might have become one of the country's foremost steel men, as negotiations were under way at that time looking to his going to Youngstown as a partner in a steel plant being organized there. Captain Jones was not only an able practical steel man but also a gallant soldier, having served with distinction in the civil war, from which he emerged as captain.

Development of Steel Production

Naturally, the rapid development of the iron industry was closely followed by an equally impressive growth in the production of steel, and this was characterized by the same astonishing increase in the efficiency of machinery and



JAMES PARK, Jr.

A Pioneer in the Manufacture of Crucible Steel

methods for fabricating the product into the countless forms in which it is marketed to-day.

It is uncertain when the first "blister" steel was made in America, but we know that up to 1831 the annual output had been less than 2,000 tons, and that little crucible steel had been made here. In 1860 we were still dependent on Europe for practically all of our steel requirements. The Bessemer process was then known, but as a dispute had arisen over its invention and an "interference" with the Bessemer patents had been granted to William Kelly, the process was not put into general use in this country until after 1860.

I have referred to Mr. Kelly's visits to James Ward at Niles in connection with his invention. These occurred while I was a member of the Ward household, and the matter was discussed at the Ward table. On one of these visits Mr. Kelly was much exercised over the fact that he had neglected to patent his discovery, but he still had great hopes that he would yet be able to reap the rewards of it, in spite of the fact that Bessemer had been granted a patent a few days before his application was filed. I cannot recall the date of this occurrence, but it must have been in 1857 as the patents were granted in this country in 1856.

Credit Where Credit is Due

As a matter of fact, neither Bessemer nor Kelly is entitled to the honor of inventing the Bessemer steel process. Kelly had, years before Bessemer began his experiments, conceived the idea of decarburizing iron by a blast of air, and had actually used the process in the making of iron, which he used and sold in place of that produced in the refinery and run out fires then employed. Sir Henry Bessemer conceived the same process and carried it out with a much more efficient mechanical appliance, which has been changed but little in general design to this day. But neither of these men was able to make steel. All they accomplished was to remove from pig iron the silicon and carbon. Robert Mushet was the man who first found out how to make Bessemer steel by recarburizing the iron after

The First Mill for Rolling Boiler Plates in America, Built and Operated by the Lukens Iron & Steel Co., Coatesville, Pa.

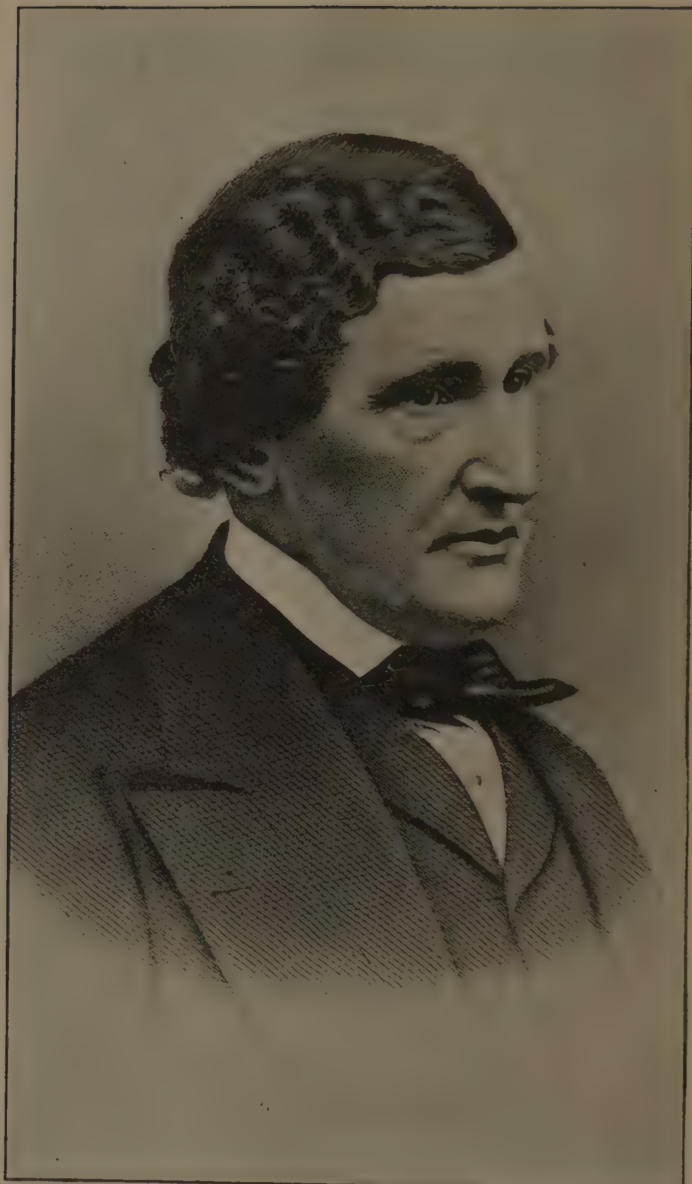
it had been blown in a converter. Kelly reaped very little benefit, also, but he will always be regarded by Americans as the actual discoverer of the fundamental element in this great process, and the little converter which he had made at the Cambria Iron Works and used there with more or less success in 1861 and 1862 is an enduring monument to the spirit of discovery and the persistent effort which have made the steel business what it is.

The manufacture of Bessemer steel in this country did not attain any headway until 1867, but when it did finally start its results were tremendous. It built the railroads of the United States, as well as most of our sky-scrapers, bridges and ships. Yet in spite of this fact, it now seems destined to give place to an older and more expensive process, that of the open-hearth; and this, in turn, will probably yield supremacy to the electric furnace, so rapid are the changes and so eager the industry to keep pace with modern knowledge and invention.

The first bar iron was rolled in New England about 1825, and the first puddling in this country was done in 1835, both at the Boston Iron Works. The first successful American blast furnace of which there is a reliable record was built in the Ramapo mountains in 1800 or a short time prior to that date. According to the *Engineering Record,* its ruins are still to be seen there.

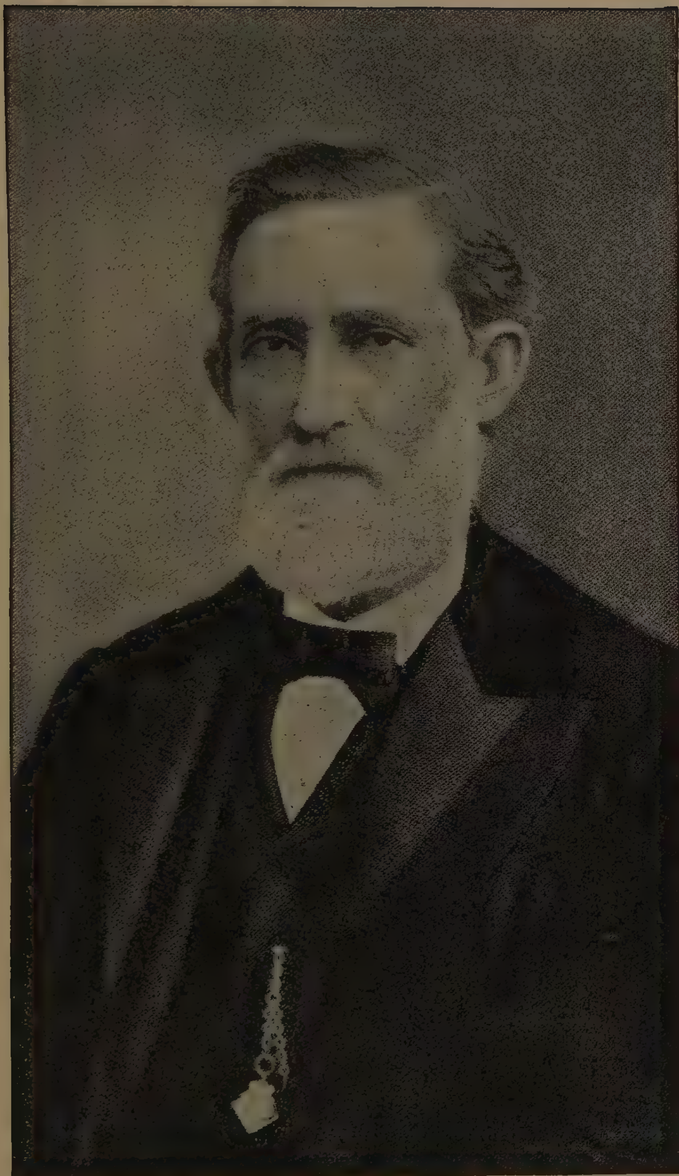
The first successful iron-working plant was on the Hudson, at Cornwall, where some Cornish iron workers gathered soon after the middle of the eighteenth century. It was a simple bloomary and forge. In 1780 a forge at West Point, doubtless an outgrowth of the establishment at Storm King Mountain, produced a great chain which was stretched across the Hudson to prevent the British gunboats from passing up that stream. That chain still holds the honor of being the largest ever forged, a fact which shows that our ancestors could rise to great efforts when inspired by patriotism, even as we are doing to-day.

I occasionally go into the blooming mills at the Brier Hill plant, where we break down a steel ingot in less than a minute, and mentally compare the massive machinery in use



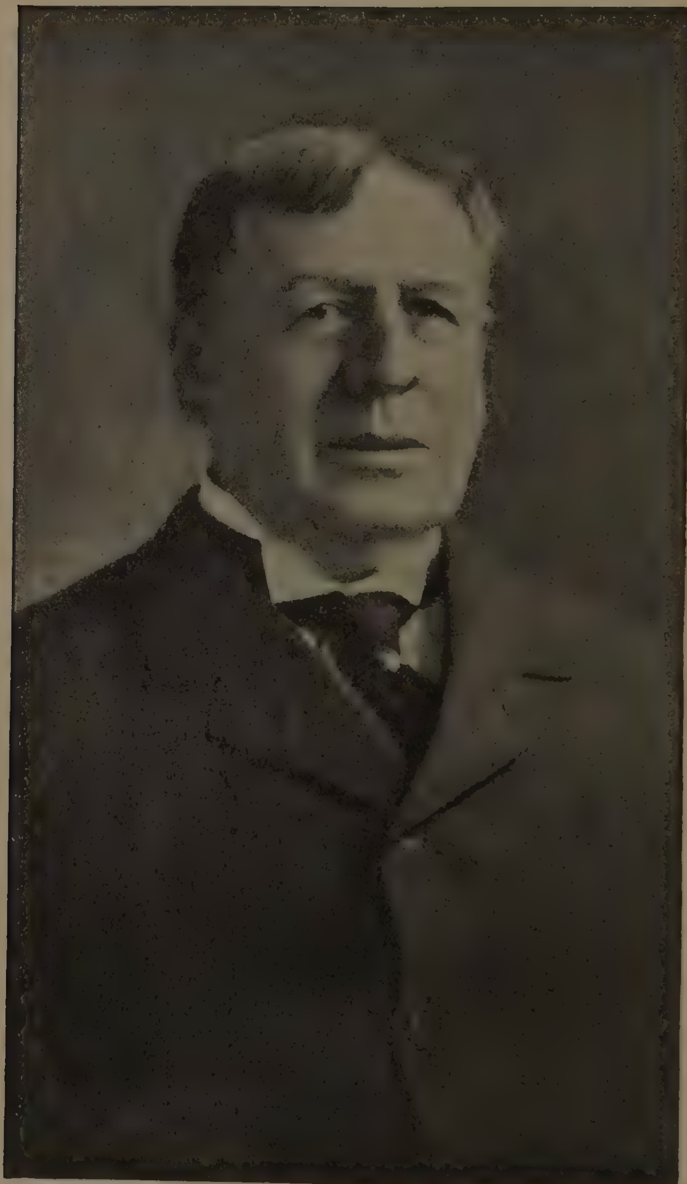
CHARLES E. SMITH

First Statistician of the American Iron Trade



JAMES M. SWANK

Author and Statistician. For Exactly Forty Years the Faithful Secretary and Guiding Spirit of The American Iron & Steel Association



ANDREW WHEELER

Treasurer of The American Iron & Steel Association

in modern steel plants with the equipment of those days. Still we had achieved a good deal even then. The first successful rolling mill in this country was about as primitive compared with the equipment of sixty years ago, as was the old Ward mill when compared with a modern rolling mill.

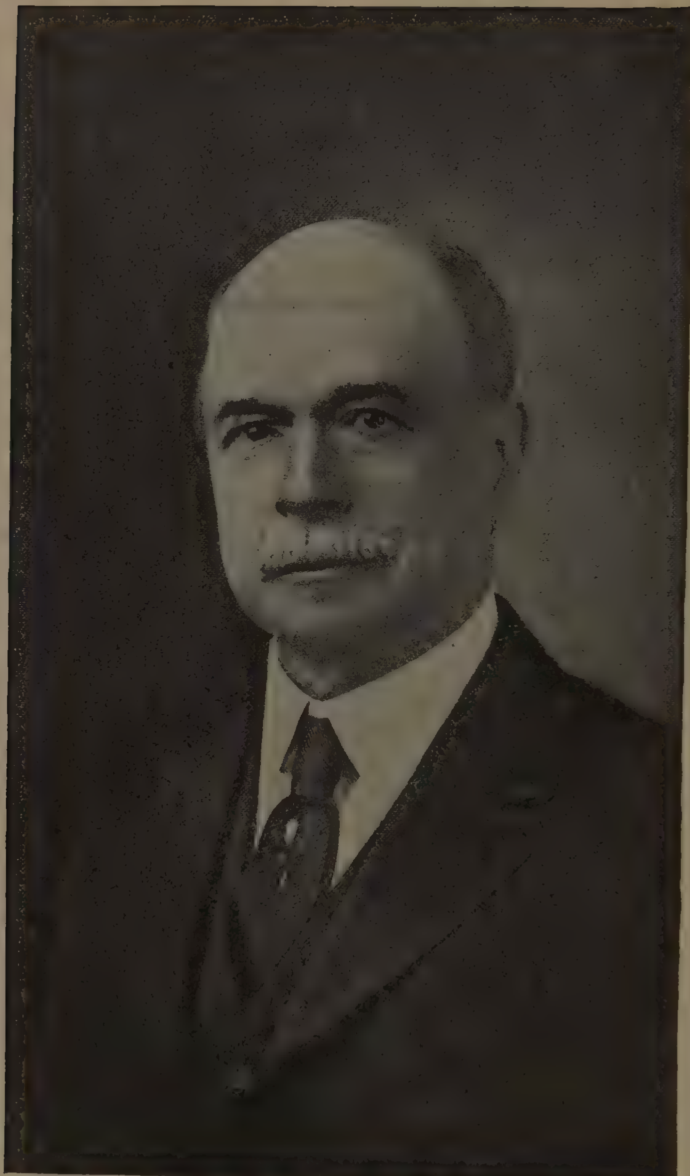
The pioneers started with nothing. We had at least something to work with. Both they and we of this generation have made the best of our opportunities, and the result is the majestic industry which to-day stands without a rival in the efficiency of its processes, in the zeal of its operatives, and in its far-reaching effect on human welfare and happiness.

Much of this great progress has been undoubtedly due to the men who have been engaged in the iron and steel business. In justice they must be given credit with a degree of enterprise found in no other industry. They have been willing at all times to face ruin for the sake of adventure into new and more promising fields. They have rewarded courage, vision and genius as no other industry has rewarded these things. They have constantly looked forward to higher achievements, scorning the contentment that sometimes brings stagnation to a great industry.

All of this progress, however, cannot be credited to the men of the industry. Some of it was undoubtedly due to the greatness of the country, the magnificence of our natural resources, and the enterprise of our people as a whole. In no other country in the world, for instance, could there have been a demand for railroad expansion such as to require 500,000 miles of steel rails in less than thirty years, as was the case in this country between 1865 and 1895.

Development of Steel Fabrication

Not less remarkable are the changes that sixty years have witnessed in the fabrication of iron and steel. When I first entered the business, the plant of my employer consisted of a small blast furnace, a refinery forge or two, and a mill upon which we rolled iron bars for various purposes. After the pig iron had been refined in the furnace, a process somewhat like that of puddling, it was rolled into muck bar. This was then made up into bundles, reheated and



ROBERT W. HUNT

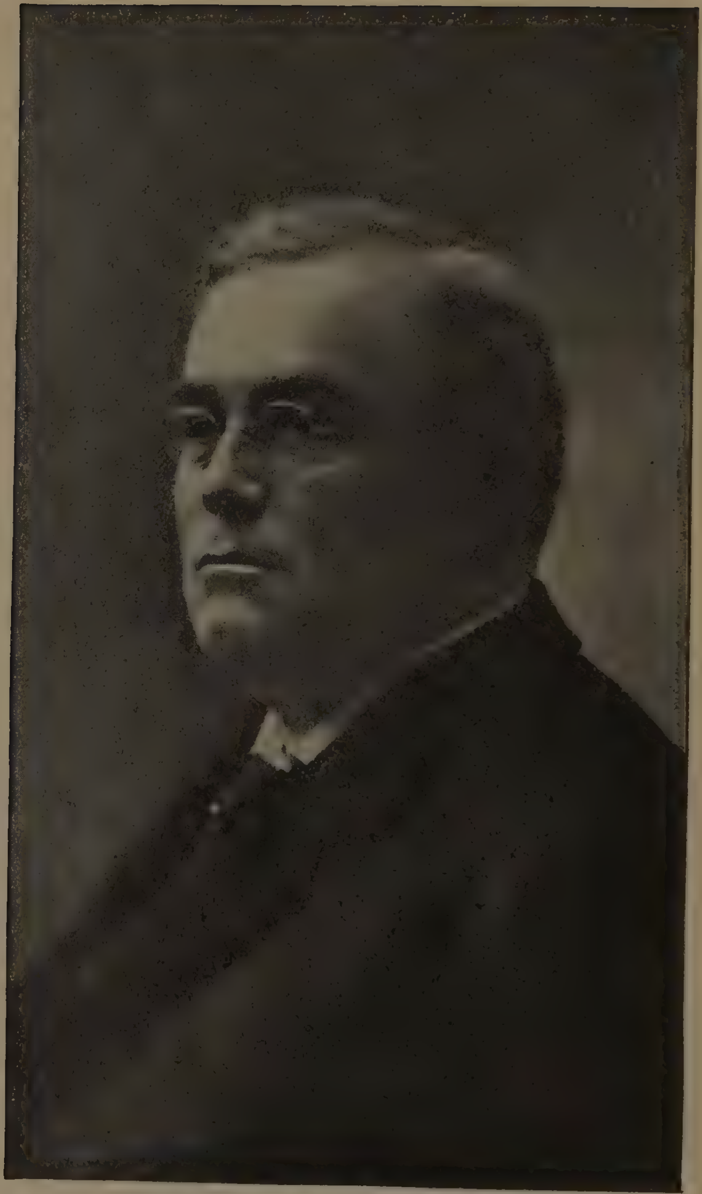
The Noted Mechanical Engineer Who Rolled the First Commercial Order of Steel Rails Filled in this Country at Johnstown, Pennsylvania

rolled on a primitive form of bar mill. My first contribution to the efficiency of the plant was a plan to regulate the size of these bundles so that they would produce a bar of the size and length desired and thus eliminate excessive waste from scrap as each piece was rolled. It was recognized as a new idea and Mr. Ward complimented me highly.

The first steel rail rolled in America from American steel was made at the North Chicago Rolling Mill on May 24, 1865, from steel ingots made at Wyandotte, Michigan. The ingots were made under the direction of William F. Durfee, who had built the first successful Bessemer converter at Wyandotte. Steel made in this converter was used in rolling the rail referred to. I was attending a meeting of the American Iron and Steel Association in Chicago at the time and went with the party that visited the works to see the operation repeated the following day. Three rails were rolled on each occasion, and a part of one of them was cut off and sent to the meeting, where it naturally attracted much attention. By 1890 more than 19,000,000 tons of steel rails had been rolled in this country, practically all of them from Bessemer steel. In 1916—which, as you all know, was not a good year for the rail business—the output was 2,854,518 tons. Of this production in 1916 2,269,600 tons were rolled from open-hearth steel, showing the great development of that process during the intervening years.

Some Noted American Iron Men

Although Mr. Durfee deserves the honor of having built the first successful Bessemer converter in this country, the steel made in it was actually an infringement on the Bessemer patents, which were then in dispute. These patents were afterward bought by the firm of Winslow, Griswold and Holley, who built the first commercial plant for making Bessemer steel at Troy. Mr. Holley helped to develop the original converter at Wyandotte until it was on a commercial basis. He later assisted in the building of a plant at the Cambria Iron Works, and next built the Bessemer plant at the Pennsylvania Steel Works, which was erected and operated under the combined patents of Bessemer and Kelly, who had in the

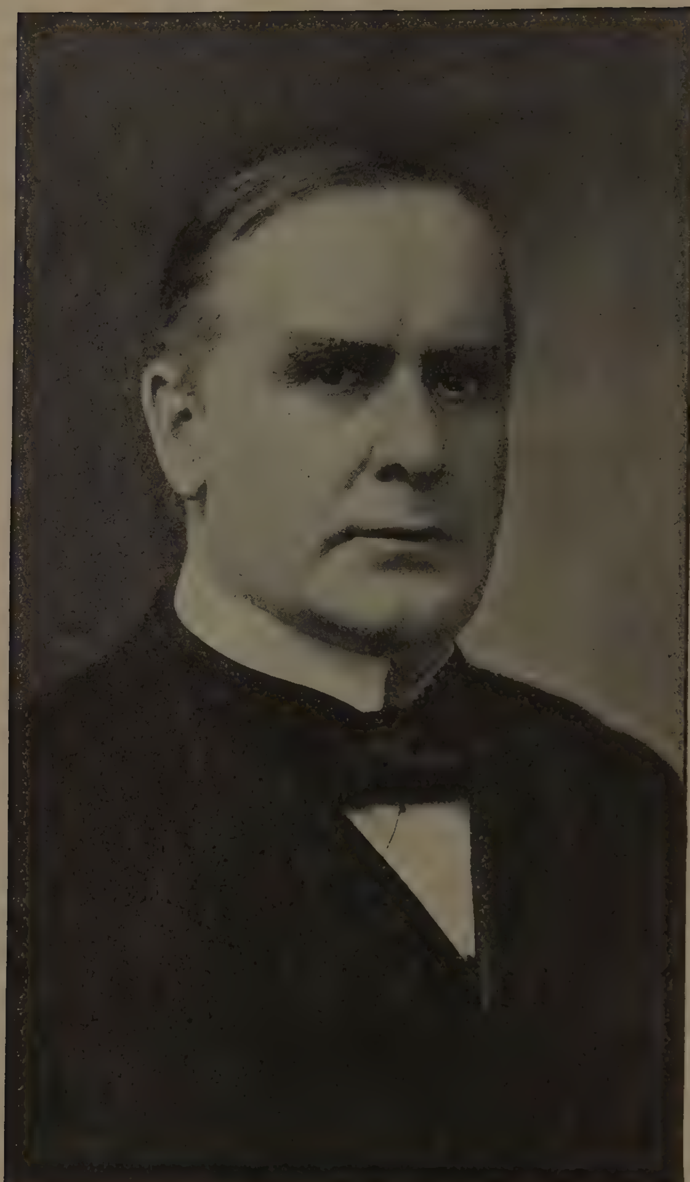


SAMUEL T. WELLMAN

Pioneer in Steel Manufacture. First to Successfully Operate the Open-Hearth Furnace in America

meantime reached an agreement. There were only thirteen plants built in this country down to 1881, but from that time the growth of the manufacture of Bessemer steel in America was very rapid. The first commercial order of steel rails filled in this country was rolled by the Cambria Iron Company in 1867 under the direction of Robert W. Hunt.

There has been an impression that William F. Durfee had much to do with the early development of the open-hearth process in this country, but this seems to be an error. He was largely occupied with the Bessemer process, but the credit of building the first successful open-hearth of the Siemens-Martin type is due to Samuel T. Wellman, of the Wellman-Seaver-Morgan Company. Mr. Wellman built the first really successful American open-hearth furnace at the Bay State Iron Works, South Boston, in the latter part of 1869. He had been assistant engineer for J. T. Potts, who had been sent to this country by C. W. Siemens to assist in the starting of an open-hearth furnace at Trenton for Cooper, Hewitt & Company, who had bought the Siemens rights. This furnace had not been successful, owing to trouble with the gas producers and other difficulties, and was finally abandoned. In working on this furnace Mr. Wellman acquired experience that made it possible for him to correct errors in design that had proven fatal to the Cooper-Hewitt experiment. It was at this plant also that the first ferro-manganese was made in this country. A full account of this interesting stage in the development of the Siemens-Martin regenerative furnace was given by Mr. Wellman in a paper read before the American Society of Mechanical Engineers in 1901, at which time he was president of that body. Like almost all great improvements, the open-hearth furnace involved much costly experiment and many heart-breaking failures. The first open-hearth furnaces had a capacity of only five or six tons at a heat, and they had none of the mechanical appliances for pouring or for casting ingots now in use. Development both as to size and mechanical operation has been gradual, and but little change has been made in the method of pre-heating the fuel gases.



WILLIAM McKINLEY

The Most Prominent Advocate of the Policy of Protection to American Industries. Twenty-fifth President of the United States

The Tariff an Important Factor

To one who can recall the early years of iron and steel manufacture there is nothing more inspiring than the ceaseless effort of men engaged in the industry to find better and more economical methods of producing iron and steel. To this must be ascribed in large part the phenomenal advances made in America, which has led the world in the perfection of metallurgical processes and the adaptation of mechanical appliances for these processes.

In like manner there is no question that a part of the development was due to the tariff policy, which for a great portion of this period encouraged enterprise by protecting the struggling iron and steel industries against competition from abroad and assuring reward for energy and ability expended in this direction.

You will pardon me if I claim some small part in this, for it was my privilege to be consulted freely by William McKinley during the period in which he labored so faithfully and effectively for wise tariff legislation, and to enjoy his personal friendship and confidence during his entire public life including his service as Congressman and his administration as President. One of the most gratifying tasks of my life has been the effort to repay in some small measure the debt owed by the industries of America to this statesman, whose broad vision had so much to do with our national growth, by conceiving, planning, and, with the help of my friends in these industries, erecting to his memory at Niles, Ohio, on the spot where he was born and where we played together as boys, one of the noblest and most beautiful memorials on the American continent. This structure was dedicated on October 5, 1917, and I hope you will permit me at this time, although it may seem foreign to my subject, to extend to every member of the Institute an invitation to visit it. It has cost approximately half a million dollars and is artistically worthy of its purpose.

I have had the honor to be consulted by the men who framed every tariff bill passed by a Republican Congress since 1875, and have tried to consult with the framers of

DANIEL J. MORRELL

Pioneer of the Policy of Protection to American Industries

every Democratic tariff bill during the same period. In preparing data for this paper I came across a voluminous report on industrial conditions, prepared by me in 1912 at the special request of William H. Taft, then President of the United States, for the use of the Ways and Means Committee at work on the tariff changes contemplated at that time. This document was submitted to Mr. James A. Farrell and it was thoroughly endorsed by him, so it must have had some merit. You may rest assured that in these activities—whether they were solicited, or, as was sometimes the case, not over-enthusiastically received—I always had in mind the welfare of the country through its industries, and I am sure that these did not suffer from anything I said or wrote upon the subject. (Applause.)

Broad Vision of Leadership

Still more helpful was the influence of the organizations created and fostered by men of vision in the two industries. Long before it came to be generally realized these men saw that the true basis of success in manufacturing enterprises is not so much unreasoning competition as sensible co-operation, and they early put their views into effect by the organization of such associations as the American Pig Iron Association and the Bessemer Pig Iron Association, both of which it was my privilege for many years to serve as President, the American Iron and Steel Association, and our own great association, The American Iron and Steel Institute. It would be hard for anyone to estimate what has been accomplished by these organizations toward the stimulation of progress and the conservation of resources in these two lines.

Even those least friendly to the iron and steel interests must acknowledge that they have led all others in this country in the way of advanced ideas along sociological lines. This has been particularly true of The American Iron and Steel Institute under the able administration of Judge Gary. We have been the first to realize the great truth that business success depends upon co-operation rather than upon competition, a truth now generally admitted.

HON. ELBERT H. GARY

The Foremost Figure in the Iron and Steel World of Today

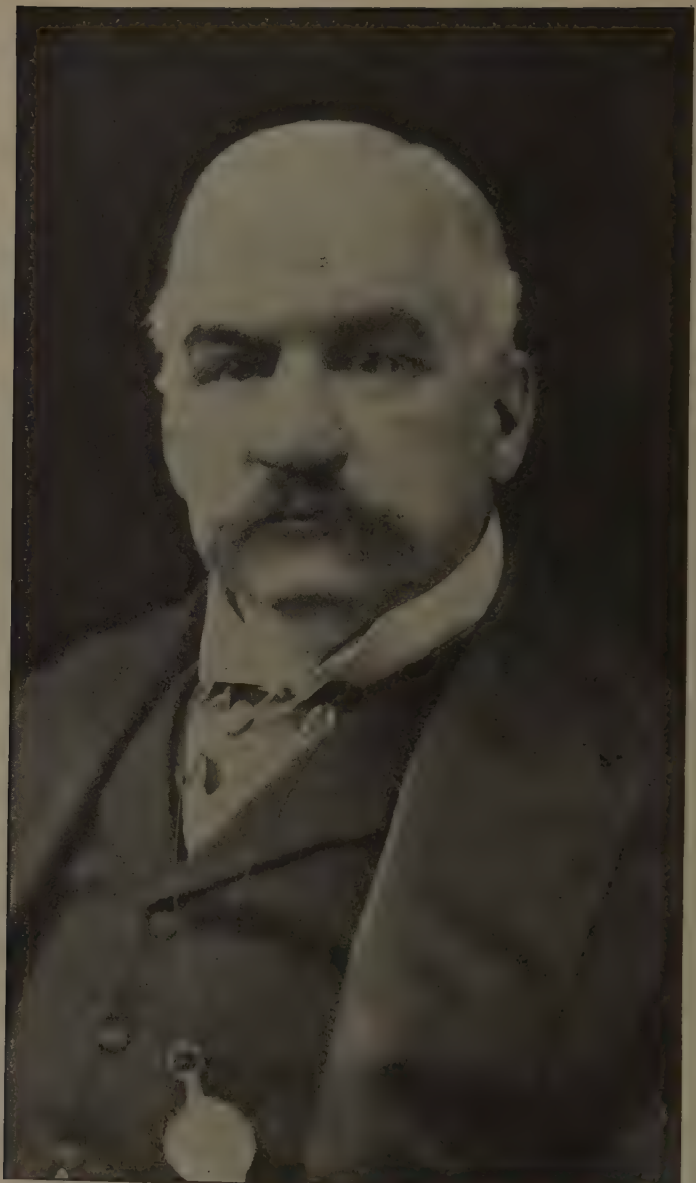
We have been the most generous of all the industries in dividing with labor the rewards of business. We have led all other industries in the matter of safety, sanitation and welfare work, and we have done more than any other to establish in the public mind the fact that the interests of labor and capital are identical, the prosperity of one involving the prosperity of the other, and that both owe to the public duties equal to those they owe to themselves.

The United States Steel Corporation

The history of the American iron and steel industry has known no incident of more far-reaching importance than the organization of the United States Steel Corporation. It is the greatest industrial and financial aggregation in the world, producing a larger tonnage of steel and iron than any single country on the globe except the United States.

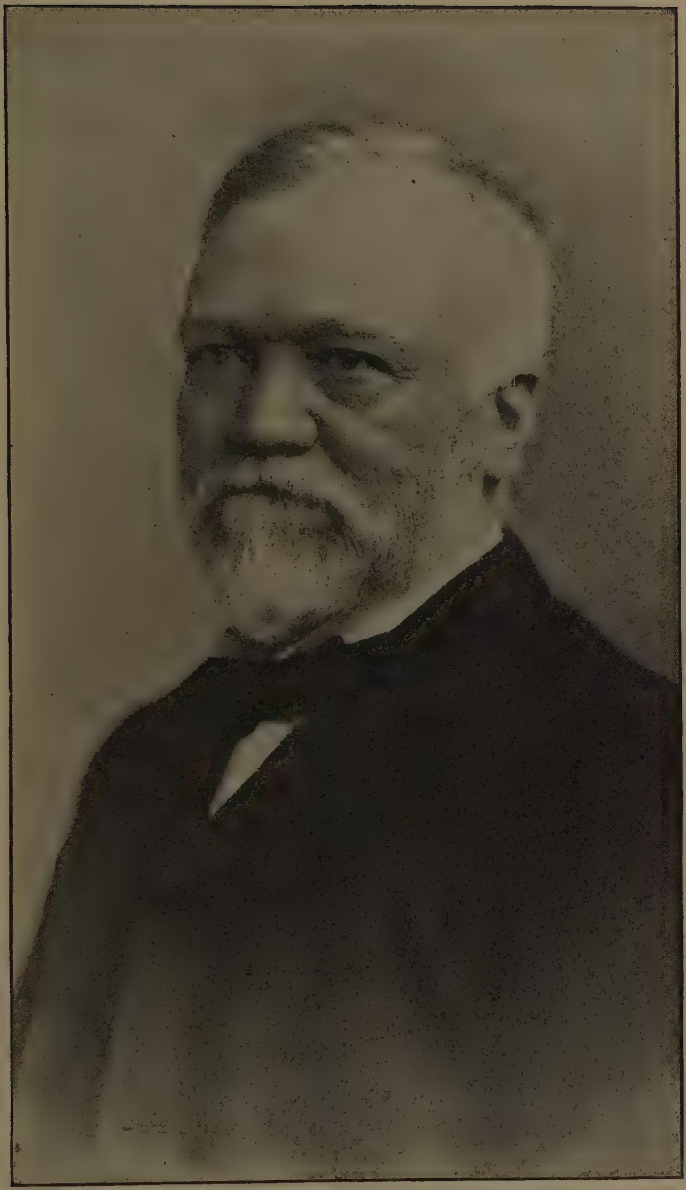
The United States Steel Corporation was formed as the result of a growing conviction among men engaged in the manufacture of iron and steel that, if the remarkable progress of this country along these lines was to be maintained and the competition of foreign countries successfully met, some method would have to be devised whereby greater efficiency could be obtained and more stable market conditions secured. History relates that the Corporation was conceived in the brain of Elbert H. Gary, who was then President of the Federal Steel Company, but it was a long time in being born.

As production mounted during the years between 1870 and 1890, conditions became exceedingly bad. Ruthless competition was the order of the day. Price-cutting, unfair methods of business, and all the evils attendant on the desire to secure markets became so prevalent that an effort was made to reach some sort of stability by the famous "pools," which many of you will remember with amusement, because their only effect was to show that agreements of this kind without the proper spirit behind them are even less than "scraps of paper." The first serious effort to improve conditions was the combination of a number of companies producing different lines of finished steel. Several of these



J. P. MORGAN

The Most Eminent Financier of the Nineteenth Century. Prominent in the Formation of The United States Steel Corporation



ANDREW CARNEGIE

For Many Years a Dominant Figure in the Iron and Steel Industries

CHARLES M. SCHWAB

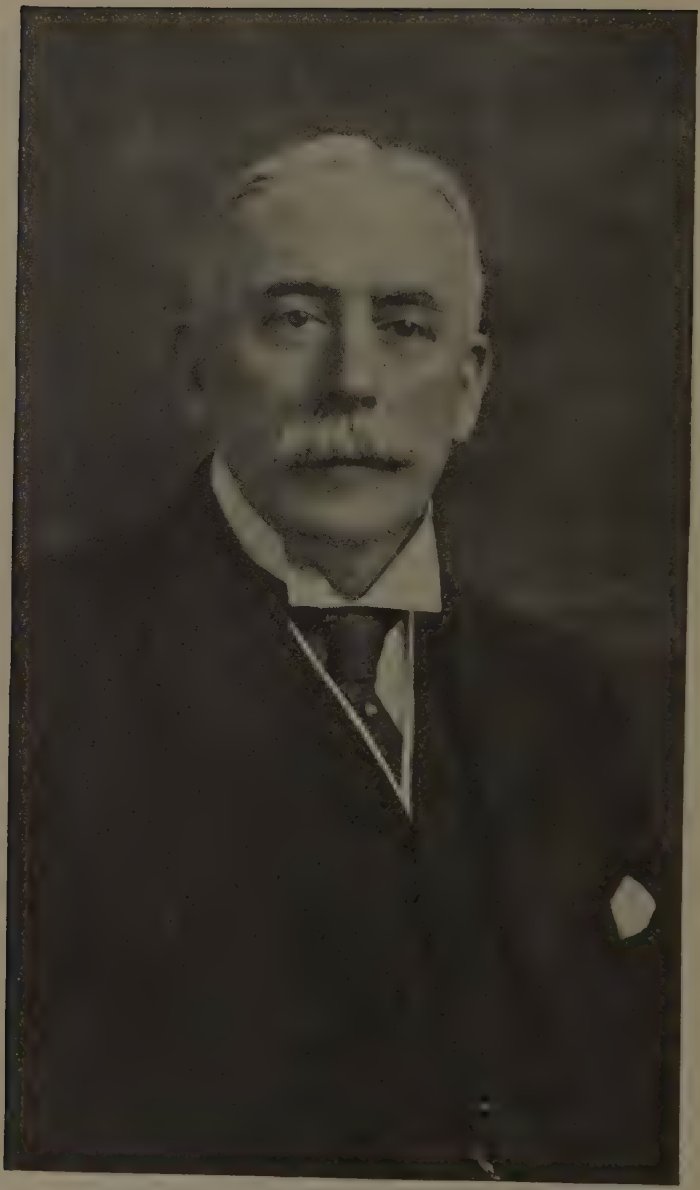
A Most Interesting Figure in the American Steel and Iron Industries. Author, Orator, Musician—A Genius in Steel

came into being in the late nineties, but they went after one another in precisely the same spirit that the original companies manifested, and the only result was competition fiercer and more relentless than before.

Judge Gary had tried to organize a great combination, and had turned for financial assistance to the late J. P. Morgan, then the only man in the United States who could influence the necessary capital. Morgan was unresponsive and nothing was done. Finally, however, Judge Gary succeeded in interesting Andrew Carnegie, then a commanding figure in the steel world. Carnegie doubtless realized the fact that the policies followed up to that time were unwholesome and he was willing to sell out to such a combination, because he felt that sooner or later his great company would find a rival, or a combination of rivals, that would be its equal, and then would come a battle royal in which he might suffer with the rest.

On the evening of December 12, 1900, two New York men, both warm friends of Carnegie, arranged a dinner in New York. To this they invited Morgan and others, among whom was Charles M. Schwab, then President of the Carnegie Steel Company. At that dinner Schwab made the speech of his life. He painted the possibilities of such a corporation as Judge Gary had been trying to form, and painted them in such vivid colors that, after the dinner was over, Morgan took him to one side and spent the greater part of the evening in talking over the matter. The result was that the financier's hesitation vanished and he asked Schwab to learn Carnegie's price. This price was slightly more than $492,000,000, the largest sum that had ever been paid for anything bought in the world up to that time.

The Steel Corporation was chartered early in 1901. It began business with ten of the largest companies then in existence. It had a capital of $1,404,000,000. Its properties consisted of 161 separate rolling mills and steel works, 73 blast furnaces, vast holdings of ore lands, coal and limestone, 112 steamships, and 1,000 miles of railroad. Its productive capacity was estimated at 7,900,000 tons of pig iron, 9,400,000 tons of steel ingots, and 7,400,000 tons



JAMES A. FARRELL

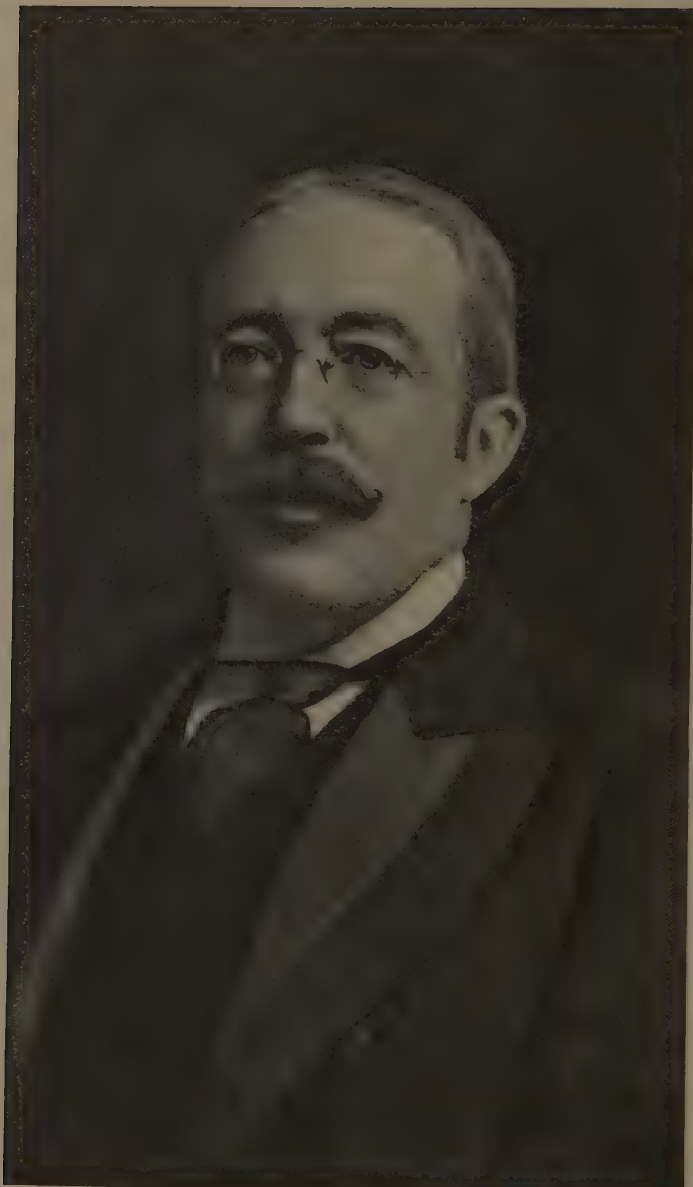
President of The United States Steel Corporation. An American Who Thinks in International Terms

of finished steel per annum. Its board of directors included practically all of the very wealthy men then in the United States, and it had on its hands the biggest problem of industrial operation ever undertaken by any set of men.

The Steel Corporation was regarded pessimistically by most of the practical steel men at that time. It was believed to be top heavy, and in the light of our experience as to methods of business, most of the independents were much afraid of it. We did not then appreciate the high ideals of the man who first conceived it; nor did we understand that part of his dream, now realized, was an entirely new principle in business conduct. The idea of co-operation, rather than competition, in business was then untried, and most of us thought that it was impractical. We have seen it worked out, and we now know that this idea is basically sound. We have had occasion to know by experience that the United States Steel Corporation, managed as it has been, has been a most excellent thing for the iron and steel industries in this country and the world, and, so far as I am aware, there is not an independent steel company which has not benefited by the broad policy it inaugurated and made possible for all of us. (Applause.)

The effect of the Corporation's activities and its policy has been good from every point of view. It has benefited its workingmen, its stockholders and the public. Many new companies which have been started since it began business have found that it was actually an aid toward their success.

So far as results are concerned, the Steel Corporation must be regarded as one of the most successful enterprises in American history. It has decreased the number of steel works under its management by dismantling several that were unprofitable in operation, so that it now operates 143 plants, instead of 161, as at the beginning; but it has increased its productive capacity considerably over 100 per cent. At the same time, owing to the phenomenal growth of the industry during this period, it now controls a smaller proportion of production in this country than at the time of its entrance into the business, its production being only about 45 per cent. of the whole in 1916.



SAMUEL MATHER

Director and One of The Founders of The United States Steel Corporation. Leading Spirit in the Development of Lake Superior Ore Industry

Perhaps the greatest service rendered to the steel industry of America by this great corporation has been the extension of our export trade. Under the able direction of President Farrell this branch of the market, formerly neglected, has been studiously cultivated, with marked advantage to the reputation of American iron and steel products in all parts of the world.

The story of the United States Steel Corporation forms one of the most interesting chapters in the history of the iron and steel industry of America and will always be one of the important happenings in the industrial and financial history of the world. It has established the fame of Elbert H. Gary, Chairman of its Board of Directors, since the beginning; J. Pierpont Morgan, whose financial genius and power made it possible; George W. Perkins, who, as chairman of its finance committee, found arduous tasks in its first years; Charles M. Schwab, who, as its first president, piloted it through the troublesome period of its organization; William Ellis Corey, who was its president for years; James A. Farrell, now occupying that responsible position; and many others.

Among those who have done most to make the Corporation a success without any effort to claim credit is Henry Clay Frick. Even before Mr. Frick began actively to devote his attention to the corporation he was on its board of directors and was recognized as the most forceful individual in the trade. He had, in his relations with Andrew Carnegie, done inestimable service in blazing the way for a better understanding of business honor and rectitude. These relations and their outcome form an incident so striking that I should like to say something further concerning them. However, to those familiar with the matter it will be sufficient to say that these relations probably had a good deal to do with the formation of the Steel Corporation, and that their outcome illustrates the fact that, in the steel business as in other walks of life, ability usually wins. Mr. Frick remains one of the most important figures in the industry, and his work on the Finance Committee of the Corporation has added to the universal esteem and respect in which he is

JULIAN KENNEDY

To Whose Engineering Genius the World's Progress Owes Much

held by all who are familiar with the industrial and financial history of our country.

Friends Who Have Made Good

It has been my privilege to enjoy the personal acquaintance and friendship of almost every man who has been prominent in iron and steel in America, as well as many of those who have achieved fame abroad. Among these are many who have closed long and honorable careers, and many who are still in the heyday of their usefulness. But even more gratifying to me is the fact that in my experience it has been my pleasure to have, in a certain sense, been tutor and friend to many young men who have since proven their ability and energy by reaching positions of high usefulness and reputation. Julian Kennedy, whose career as an engineer has benefited the iron and steel industries in all parts of the world, came to the Mahoning Valley as a young man just out of college, and while we thought he was rather too fond of rowing a boat on the little river there, he was evidently not wasting his time in fishing while doing so. Mr. C. A. Meissner, who is known to most of you as chairman of the coke committee of the Corporation, was our first chemist at Brier Hill, and the first chemist, for that matter, employed at any of the furnaces in that locality. While with us he distinguished himself by making first-class "Scotch" pig iron out of Lake Superior ores, and while we had at first to keep a little imported Scotch pig around for the benefit of doubting Thomases, it was not long until "Brier Hill Scotch" was in strong demand all over the country. W. B. Schiller and F. B. Richards and the late J. H. Sheadle are also Brier Hill by-products.

I would like also to claim credit for our young friend Charlie Schwab, but my old friend Carnegie got hold of him first, and Andy always knew a good thing when he found it. Nevertheless, I wish to pay the compliment to Mr. Schwab of saying that he could hardly have done very much better had he been educated at Brier Hill. He has built up in the Bethlehem Steel Company, an institution which is a Krupp and a Creusot combined, with some advan-

JAMES A. CAMPBELL

President of The Youngstown Sheet & Tube Company. A Commanding Figure Among Executives Who Have More Recently Achieved National Reputation

tages over both. (Applause.) So long as we have young men coming on with the brains and energy of those who are to be found in the various iron and steel organizations, the future of these industries in America is safe, and the country is safe also.

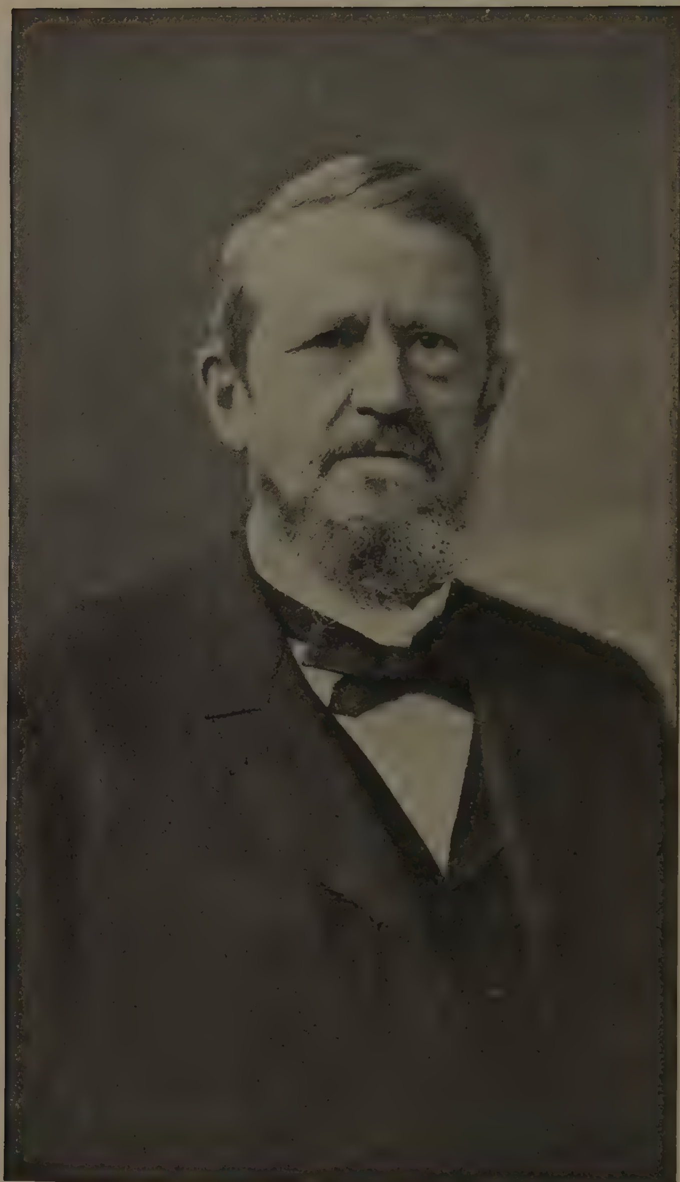
The Kaiser's Big Mistake

In 1916 I spent six weeks in France and England with the American Industrial Commission. Had not what I saw there been sufficient to impress upon me the importance of the American iron and steel industries in the world's struggle against despotism and scientific barbarism, the statements made to me by the leaders of the French and English people would have done so. Without the magnificent resources of our mines and mills the Allied cause would have been lost long ago. The genius, the energy and the rectitude of purpose that made possible the splendid industrial development of America has also made possible the preservation of democracy. There can be no doubt whatever on this point. Our Government was not ready, but our mills were prepared. The biggest thing the Kaiser overlooked in his calculations was the American iron and steel industry. (Applause.)

It has been our great privilege, gentlemen of the Institute, to render aid on behalf of the world in the supreme hour of history. We are now called upon to make sacrifices in the same great cause, recently brought more directly home to America but scarcely more ours now than it was at the beginning of the war. That we shall do so with energy and devotion characteristic of our history and in keeping with our traditions, I have not the slightest doubt.

We Have the Confidence of the Public

One of the things of which iron and steel manufacturers have a just right to be proud is the present attitude of our government toward them. In times of peace Washington has shown a disposition to amuse itself and entertain the public with efforts to regulate our corporations, but



JOSEPH WHARTON

A Pioneer in the Manufacture of Iron and Steel in Eastern Pennsylvania and New Jersey. Founder of The Bethlehem Steel Company

in time of war it turns to them without hesitation, finding them eager to render every service. At this time the Government, through the War Industries Board, has prescribed certain basic prices for steel products, but at the same time it has shown its faith in the manufacturers themselves by asking them, through The American Iron and Steel Institute, to arrange the details by which these prices may be made an actual fact. Under these circumstances, the fixing of prices has actually been done by patriotic manufacturers themselves, rather than by the Government, and the manner in which the interests of the nation have been given preference is a striking testimonial to the high ideals existing among these men.

Excelsior

As Doctor Oliver Wendell Holmes said: "Youth longs and manhood strives, but age remembers," and this is my excuse for indulging in reminiscences before a body of busy men intensely interested in the present and the future. To me it seems that this future can be gauged accurately from the present and the past. The early days of iron making in this country are radiant with the spirit of progress and of patriotism. This spirit had no small part in making America "monarch of all the forges," and it has not died out. We can depend on it to still preserve the wonderful lead we have attained in production, and to maintain the institutions to which we owe so much of all that is good for us and for the world.

It is as true to-day as it ever was that the civilization of a people may be told by their progress in the use of iron and steel, and I hope the time will never come when America will no longer lead all other nations in this respect. I hope also that the time will never come when men in our industry will show less public spirit or less patriotism than in the past. In the present crisis of our national life we need the high purpose and the unselfish devotion to country that our members have shown. We need the courage and vision of Judge Gary, our President, and we need as never before the energy and ability of our younger manufacturers.

Aside from this duty to aid our country in every way possible by the efficient operation of our properties and the ready co-operation with the Government already shown, our chief duty, as I see it, is to preserve the traditions and continue the splendid record of the industries in our care. There is still much to be done. The limit of advancement has not been reached. In the future lies opportunity as great as that of the past. It must be grasped by younger men, for we older ones have reached the summit from which the prospect most alluring lies behind us. If the facts and reminiscences to which you have so patiently listened to-day give you inspiration to carry out the traditions and to emulate the past performance of the great industries in which you are fortunate to be engaged, they will have accomplished their purpose and I shall have my reward. (Long continued applause, the entire audience rising.)

PRESIDENT GARY: A paper on Malleable Iron and Its Uses by Mr. Pope of Cleveland.

MALLEABLE IRON AND ITS USES

Henry F. Pope

President, The National Malleable Castings Company, Cleveland, Ohio

It is well to give a little time to the consideration of malleable iron, for by many its characteristics are little understood.

Iron, as it is run from the furnace and poured into the molds in the process of making malleable iron castings, is not malleable at all but is extremely hard and brittle. When broken, it shows a white fracture. But this brittle iron is of such composition that when subjected to the proper annealing heat for the requisite length of time, it is transformed into an iron with entirely different physical qualities. After annealing, instead of showing a white fracture it shows a black one, giving it the name of "Black Heart." This distinguishes the malleable iron made in this country from that made on the continent of Europe, which has a steely fracture, due to the fact that the carbon is almost entirely removed by oxidation in the annealing process. Graphitization of the carbon is more easily controlled commercially than oxidation; therefore, the "Black Heart" is the more reliable product. The black fracture of our iron is due to the fact that in the annealing process the carbon, which in the original casting was all combined, has been separated out by decarbonization and is now found as free carbon or graphite of non-crystalline form deposited between the molecules of the iron. This form of carbon is called by Ledebur "temper carbon," to distinguish it from its other forms. The presence of a large amount of temper carbon gives the material its black appearance.

The iron itself, therefore, is left almost entirely free from any combination with carbon and possesses the malleable quality of wrought iron. It can be bent without fracture and withstands great shock and stress without breaking. It has the superiority of wrought iron in the respect of malleability without the sometimes objectionable fibrous structure of that ma-

terial and with the very great advantage that it can be cast into all sorts of intricate shapes without difficulty, saving the large cost of laboriously shaping and building up the wrought iron. And this is not belittling wrought iron, which has its important place. Often combinations of wrought and malleable iron are made in a structure with very distinct gain.

Some one will say: "Why use malleable iron any more when steel castings may be had?" Well, that is a very plausible question, for great strides have been made in steel casting production and certain castings have been changed from malleable iron to steel with improved results; but there are several reasons why steel will never displace malleable iron for a multitude of articles. In the first place, in most cases if the steel could be produced in the form and section of the malleable casting, it would be more expensive and no better; for it must be remembered that while the tensile strength of malleable iron is somewhat below that of soft steel, its elastic limit is just as high, which means that it will stand just as much punishment as the steel. Furthermore, it is easier and cheaper to produce many articles in malleable iron. The iron is fluid at a much lower temperature than steel. To procure steel as fluid as the iron costs more; and when the fluid steel, at a high temperature, is poured into the mold, much more difficulty and expense is encountered than with the cooler iron. The problems of the foundry are comparatively simple in the case of the iron.

Malleable iron has, unfortunately, not been produced in conformity with the best standards by all of its makers, and the poor iron made by some has brought much discredit upon the industry as a whole. There is no justification for this, because the inferior metal can be so easily distinguished from the good by the examination of the fractures of removed test lugs. All important castings should have test lugs cast on them for this purpose. Many manufacturers have, however, for several years given serious scientific study to their product with wonderfully good results, so that from many of them malleable iron can now be obtained of uniform quality and of greatly increased tensile strength without any sacrifice of ductility; for one peculiar feature of malleable iron is

that while the tensile strength increases, the elongation also increases. This is not true of any other commercial metal.

There are two essentials necessary in the production of malleable iron. One is the proper composition of the hard iron and the other the proper heat treatment in the annealing process. With increased knowledge and with better practice, the former has been greatly improved and the latter is secured by a proper observation of the temperatures. The excellence of malleable iron will doubtless be greatly increased by the use of the electric furnace, which insures certainty of proper mixture before the iron is poured, besides eliminating objectionable oxides.

Malleable iron, then, due to its unique qualities, has a usefulness which is entirely its own and which cannot be taken away. Years ago it began to be used advantageously for agricultural implements, all sorts of farm tools, wagons and carriages, harnesses, stoves, pipe fittings, and for many other purposes. Later, the railroads began to use it, for many parts of the car could be made lighter and less subject to fracture by the substitution of malleable for gray iron. The railroads use it also in places where the iron is exposed to the corrosive action of the weather, for malleable iron is as non-corrosive as any of the iron products and much more so than steel. Tie-plates, for instance, ought to be made entirely of malleable iron, for the corrosion of the steel makes it much more expensive in the end. More recently the malleability, the lightness and the good machining qualities of malleable iron, as well as the fact that it could be cast into desired shapes with ease, have made malleable iron very popular for use in automobile construction. Malleable iron has other good qualities. Its permeability is as high as soft steel and its magnetic hysteresis is less. These qualities render this material very desirable for certain electrical machinery.

It is seen, therefore, how important a place malleable iron holds in the iron and steel industry. (Applause.)

President Gary: Discussion of Mr. Pope's paper by Professor Enrique Touceda, Professor of Metallurgy, Rensselaer Polytechnic Institute, Albany, New York.

MALLEABLE IRON AND ITS USES

Discussion by Enrique Touceda

Professor of Metallurgy, Rensselaer Polytechnic Institute, Albany, N. Y.

I have listened with much pleasure to the interesting paper just read by Mr. Pope, who happens to be one of a few of the manufacturers who make both steel as well as malleable iron castings. For this reason I attach great weight to his remarks in connection with a comparison of these two products.

He has admirably set forth the reasons why there will always be a large demand for the malleable iron casting and why it has, by reason of low melting point, superior fluidity, high elastic limit, and low cost, a certain field from which it is not going to be forced by any product at present on the market. To the foregoing characteristics I would add those of superior soundness and ease of machining. I do not share, in entirety, his comparisons of the physical characteristics of malleable with those of wrought iron, but the former certainly possesses a superior elastic limit and is more rust-resistant than the latter.

When it is considered that malleable iron is a cast material and that wrought iron is hot worked; that their physical characteristics should be as close as they are is truly wonderful.

I have always been very enthusiastic about malleable iron as a metal, even from the very start of my practical experience with it, back in 1896. I felt then that I could predict for it a bright future and great possibilities provided the manufacturer would depart from the crude methods at that time in vogue and realize that he could not attain refinements with equipment that he could not control, etc. That he has certainly done this will be instantly apparent to anyone who will take the trouble to visit many of the up-to-date plants where they will find that the most approved furnaces and ovens, pyrometer equipments, testing

departments, laboratories, and live organizations have replaced the old order of things.

I not only heartily endorse his thought that there is a certain field for the malleable casting that will always be occupied by it to the exclusion of any other kind of casting, but in addition feel strongly that this field is going to be widened in the very near future, because I have lately seen castings of so superior a quality that if such can be uniformly produced there is no question whatever of their marketability in huge quantity.

It must be borne in mind that the most important step in the manufacture of this product is in the heat treatment of the white iron casting. We all know that the efficacy with which this can be done depends first, upon one's knowledge of the scientific fundamentals underlying this process, and second, in the possession of equipment that will enable one to faithfully carry out what these fundamentals indicate must be done. Improvement started with a realization of these facts by the manufacturer, and to-day his aim is to adopt any suggestion, introduce any change or install any equipment that may give promise of increasing the uniformity and physical characteristics of his product.

It is this disposition on his part that gives me faith in the thought that what I have predicted will come true. Not the least gratifying and encouraging sign is the increasing attendance at the meetings of the various technical societies of so many engaged in this industry. Where five or six years ago this was the exception, it is to-day the rule. This is but natural, for with each step towards progress comes the desire to learn more, and I know no surer, easier, and more congenial manner to absorb knowledge than through contact with the talented men who form these bodies, and from a study of the papers printed in their transactions, many of which are classic. (Applause.)

President Gary: Further discussion by Mr. F. J. Lanahan, President, Fort Pitt Malleable Iron Company.

MALLEABLE IRON AND ITS USES

Discussion by Frank J. Lanahan

President, Fort Pitt Malleable Iron Company, Pittsburgh

In addition to what Mr. Pope has said in his very able and comprehensive paper on Malleable Iron and Its Uses, it would not be amiss to direct attention to a few salient facts regarding this material and its possibilities.

As the author has stated, its characteristics are little understood, and while this undoubtedly is true with respect to a portion of users, it is an unpleasant commentary to say that it applies equally well to a small number of foundries.

Fortunately, in recent years, there has been a decided change, for a few manufacturers were convinced there were latent virtues in this product, and they, with determination, worked to develop it to the fullest extent. Quite naturally, advantage was taken of the laboratory, and the inevitable research, finding solutions to these perplexing problems with results that were extremely gratifying.

It is to be doubted very much whether the pioneer of the malleable iron industry of this country, in the early twenties—Mr. Seth Boyden—had the remotest idea of the wonderful future this material had in store.

The malleable iron industry, following the example of the larger Iron and Steel Mills, had to eliminate the "rule of thumb" practise so prevalent in foundries until a comparatively recent date. The foggy ideas of the old-timers became so entrenched in the minds of foundry operators that they placed sole reliance upon the "magic eye" of the superintendent. So self-satisfied in their own conceit were these individuals that they regarded their knowledge as to the mysteries of iron much superior to the student of chemistry. It was not without much misgiving and dubious predictions as to the outcome did the practise of mixing the irons become the lawful possession of the chemist, who had previously been considered a useless personage about

the plant. The necessity of knowing the chemical constituents of the raw material purchased was not until recently deemed necessary. This was likewise true of the product.

Through this avenue, however, the correct ratios of elements were so worked out, and it is now known that with a certain content of carbon, there should be a properly balanced silicon to give the physical properties sought. This is likewise true with respect to the sulphur and manganese. The adherence to these known ratios assures the manufacture physical properties of the highest order.

To appreciate the value of these results it was necessary to establish definite methods of testing the product. Test bars are cast from each heat for static loading, while wedges likewise are made for the dynamic test. The foundries making car castings today work under a specification, the minimum requirement of which is 45,000 lbs. per sq. in. tensile strength, with an elongation of 7½% measured in two inches.

From the results of the majority of the manufacturers working under this specification, it would seem that at a near date it will be possible to increase the requirements for this particular class of material.

A large majority of the concerns are producing an iron much higher in physical properties than called for in this specification. Here are the results of one firm for the past twelve months, who specialize on car castings. The average results were as follows:

51,000 lbs. per sq. in........ultimate strength,
13%.......................elongation,
18.5% ....reduction in area.

The maximum of these tests was approximately 57,000 pounds per square inch, ultimate, 27.3% elongation and 34% reduction. You will readily see, this shows uniformity of operation. It is not uncommon to produce an iron with a tensile strength exceeding 60,000 pounds per sq. in.

The following incident is cited wherein a period the iron ranged from 60,000 to 65,000 lbs. tensile strength with an

elongation of 9½% to 17½%. This was made possible by being able to procure exactly the kind of raw material necessary to make such metal. The physical properties are called to your attention, simply to show the possibilities of malleable iron.

In conjunction with the improved quality of product obtainable today, the founder is producing his castings sound. The question of feeding the castings with heads and risers to insure soundness went hand in hand with the increased strength. There was at one time a fallacy that a malleable iron casting could not be manufactured with a section in excess of ½″. Today in making castings for car work, foundries have not encountered any sections that engender trouble. We are making quite a tonnage of castings ranging in thickness from 1¼″ to 1½″.

The perfecting of the processes of making good malleable iron is likened to the adage, "Perfection is made up of trifles, but Perfection itself is no trifle."

The excessive demands placed upon the malleable iron industry has been due in a large measure to the advent of the automobile. It is in this field that malleable iron has played an important part in which machinability and strength have been paramount. The automobile manufacturer desires a metal that will machine easily, combined with strength and yet within a limited weight, so as not to lumber the car with excessive material.

Quite frequently in the past year and a half have the malleable foundries been called upon to make some malleable castings for railway cars where malleable iron had not been considered previously. This would indicate a renewal of faith in a material that can be depended upon when made by a reputable manufacturer, if the sections are properly designed by the engineer.

Attention need only be called to the great possibility of malleable iron for munitions in the way of grenades, fuses and various forms of bombs, to show what an important part this material can take in upholding the arm of our government in the great war of democracy. This industry in common with every allied craft composing the American

Iron & Steel Institute, holds itself in readiness to answer to the utmost of their ability, the call of the President and the Committee on National Defense, to serve the Government, with patriotic fervor to the fullest extent of the capacity of the foundries and the energy of their employees. (Applause.)

President Gary: Further discussion by Mr. F. E. Nulsen, President, Missouri Malleable Iron Company, of East St. Louis.

MALLEABLE IRON AND ITS USES

Discussion by Frank E. Nulsen

President, Missouri Malleable Iron Company, East St. Louis, Ill.

Mr. Pope's paper, in spite of its brevity, has so fully and completely covered the ground that he has left no new points for me to bring out. Nor can I differ with him on a single statement he has made. I can only therefore discuss and amplify some of the points he has brought out.

As Mr. Pope says, the manufacture of agricultural implements were the first to recognize the merits of malleable iron. American farm implements, because of their superiority, have found their way to every part of the globe. Their lightness and great strength have made them successful in competition with foreign-made implements. The ability of the American manufacturer to build a lighter and stronger machine than his competitor was due almost entirely to his liberal use of malleable iron; malleable iron, by the way, being a product which for some reason is but very little known in Europe, its manufacture being almost an exclusively American industry.

Malleable iron possesses one quality which Mr. Pope has not brought out—its ability to resist wear. Several manufacturers of malleable iron have for years been making wagon skeins of this material and guarantee their malleable skeins to outwear two or three sets of steel skeins, a guarantee they have no difficulty in making good on.

The reason that malleable iron makes a fine bearing surface is because of the presence of a large percentage of graphitic carbon.

The field for malleable iron has been greatly broadened in the past few years, due to the high cost and inability to secure deliveries on brass castings, aluminum castings and forgings. A vast number of parts, formerly made of these materials, have therefore recently been made of malleable iron. Because of its cheapness and the satisfaction it has

given, malleable iron will probably in most cases be used permanently in these new fields.

I want to lay stress on what Mr. Pope has said about the resistance to oxidation of malleable iron. I have seen tie plates made of malleable iron which have been in use for ten or twelve years and which showed scarcely a depreciable loss in thickness due to oxidation, whereas, the average life of steel tie plates, due to wastage from oxidation, is about five or six years. In this field a higher first cost has prevented the extensive use of malleable iron tie plates. Due to the present high cost of steel, a malleable tie plate can be produced today as cheaply as a steel one and railroad engineers would do well to take advantage of this condition and thoroughly test out the malleable tie plate.

We are hearing a great deal these days of the advantages of heat treatment. Heat treatment reduces the crystalline structure, removes internal strains and consequently greatly increases the ability of the material to withstand shock. Malleable iron, because of its process of manufacture, is essentially a heat treated product. Its crystalline structure is very fine and to this quality is due its ability to withstand shock and vibration and to stand up well in extremely cold weather.

The one great argument used against the more extensive use of malleable iron has been its lack of dependability. That argument, however, is rapidly disappearing. The old rule of thumb in the manufacture of malleable iron has been replaced by scientific methods. Only a decade ago it was the exception, rather than the rule, to see a malleable iron plant equipped with a chemical laboratory. Today every first class institution is not only equipped with a chemical laboratory but is equipped to make microscopic examinations which have been found to be a greater aid in the production of a uniform quality of metal than the chemical analysis. This equipment has shown the importance of temperature control, and annealing ovens in most up-to-date plants are now equipped with pyrometers connected with recording instruments, making it possible to secure almost absolute uniformity of results.

Until all plants have introduced scientific methods of manufacture, it would be well for every consumer of malleable iron to heed Mr. Pope's advice and have a small test lug cast on every casting, which will conclusively show the quality of each piece and prevent iron of inferior quality getting into service. (Applause.)

President Gary: Further discussion by Mr. J. S. Haswell, of the Dayton Malleable Iron Company, Dayton, Ohio.

MALLEABLE IRON AND ITS USES

Discussion by John C. Haswell

President, The Dayton Malleable Iron Company, Dayton, O.

Mr. Pope has ably covered in a brief and comprehensive paper a vast field, touching as he has upon every phase of the manufacture and use of malleable iron.

He has truly said that steel will never entirely replace malleable iron for a multitude of articles and it might further be said that many competent engineers are of the opinion that in numerous instances substitutions of steel for malleable have been made that were not justified and that as malleable iron becomes more thoroughly understood and appreciated it will eventually find its proper place wherever such substitutions have occurred. In time, of course, scientific design will take the place of guess work in the determination of these matters and when that day comes malleable will be in far more general use than it is today.

The scope of Mr. Pope's paper being so essentially broad it was of course impracticable for him to discuss in detail the multi-various uses of this product, hence it may not be inappropriate to refer more in detail and yet briefly to one of the particular uses of malleable iron which he mentioned. I refer to the automobile, the development of which has opened a very broad field for all kinds of steel and iron. In this great industry the most brilliant engineering talent has been developed so that while malleable iron is very largely used in motor car construction it is probably more intelligently and scientifically employed in this field than in any other, due, of course, to the exact science which the building of automobiles has already attained. Some one has probably said ere this "Where is there much malleable iron used on an automobile?" The question might be answered by asking where it is not used. The wheels, whether wood or metal, have malleable hubs; the steering gear, transmission, rear axle, springs, body, lamps, wind

shield, magneto and self starter are generally supplied with malleable iron parts, not to mention the thousand and one accessories such as license brackets, wrenches and tools innumerable. May it not be profitable to consider for a moment why malleable iron is so largely used in this industry? We will find that among the reasons is its general adaptability and great strength in proportion to area, easy machining qualities and last but not least intelligent and scientific designs. In the most popular car made in the country today, there are about one hundred parts made of malleable iron while in the higher priced cars there are about the same number.

Mr. Pope has spoken of the importance of inspection and too much stress cannot be laid on this point. Here again most industries can learn something from the automobile manufacturer. Practically all the large motor companies not only employ a corps of competent inspectors but they have established chemical and physical laboratories where scientific study is given to the characteristics of all materials used in the construction of the car. It is not unusual now for a foundry to have a defective casting returned accompanied by a chemical analysis of the product and an opinion concerning the methods employed by the foundry. While some of these opinions may not harmonize with the views of the foundryman the practice has a tendency to keep him alert and if other lines would take as much pains to relate cause and effect there would be less of arbitrary and more of intelligent and discriminating decision in the selection of metals for various designs.

Mr. Pope has also touched on the research work which has been carried on for a number of years by malleable iron manufacturers with a view to improvement in processes and product. Probably no other branch of the metal working industry has been more active in this respect so that today practices are standardized and modernized until many of the old uncertainties and difficulties are eliminated entirely. A start has also been made toward providing reliable literature for students who wish to know something of the process of making malleable castings. Our colleges

and technical schools have had almost nothing heretofore of a satisfactory nature along this line while all branches of the steel industry are liberally provided with text books and literature of a comprehensive and reliable character. It is therefore a reasonably safe prediction that malleable iron will continue to find an ever increasing and expanding field of usefulness and in the not distant future its proponents fully expect to see it replace steel in many places where the latter has been improperly substituted for malleable. (Applause.)

President Gary: So far as I understand the discussion, we may as well make it unanimous. "The Export Trade as Affected by the War," by Mr. Eugene P. Thomas, President of the United States Steel Products Company, of New York. (Applause.)

THE EXPORT TRADE AS AFFECTED BY THE WAR

Eugene P. Thomas

President, United States Steel Products Co., New York

Foreign trade, instead of being merely a contributing factor, has become an indispensable element of our industrial prosperity. Henceforth, we must accustom ourselves to regard it as vitally necessary to our material well-being, no less than to our national safety. We have come slowly to realize the significance of what is called "militant commerce." We understand, as we never did before, the consequence that its prosecution entails. In their penetration of the markets of the world, German manufacturers and merchants had behind them a government whose ideals of national greatness were purely military. German commerce was the advance guard of German conquest, and the sacrifices made to forward the one were regarded as a legitimate contribution in the progress of the other.

It was largely due to the reaching out of Germany toward world dominion that there took place in the latter part of the nineteenth century an abnormal development of the German steel industry—a development involving capacities far in excess of the apparent demand. This excess was, in some years, equal to 40 per cent. of the total production, and for the surplus thus created markets had to be found without regard to the immediate profit they might yield. Hence, during the development of the American export steel trade of the ten years preceding the war, we encountered constantly and everywhere the systematic sale of German steel at whatever prices the buyer was willing or able to pay —prices which, more often than otherwise, were less than the net cost of manufacture in Germany plus transportation charges. This was one of the results of the well-known German policy of "dumping" as a means of securing undisputed possession of a given market, and affording justifica-

tion for the existence and expansion of capacity designedly greater than normal demand required.

The War Mainly a Matter of Metallurgy

While the prospects after the war of our export trade in iron and steel and their manufactures are of present interest, due emphasis must be given to the part which metallurgy has played alike in provoking and in prolonging the present conflict. When the Germans seized and, in spite of the Allied victory on the Marne, held the Briey basin, they expected the prompt collapse of France. For this basin contained nine-tenths of all the French deposits of iron ore, and of 127 blast furnaces in active operation in 1913, 95 were in the war zone and in the possession of the enemy. Thanks to the British Navy, France still possessed the freedom of the seas, and from England and the United States were poured in supplies of munitions of war pending the utilization of unworked deposits of inferior ore outside of Lorraine. A new equilibrium between supply and demand was finally established, but it is no exaggeration to say that for months the very existence of France hung on her supplies of steel. So also, for that matter, did the victorious advance of Germany. Addressing the Imperial Chancellor on May 20, 1915, the representatives of six important industrial associations said:

> If our production of iron and steel had not been doubled since last August, it would have been impossible to continue the war. As raw material for the manufacture of these immense quantities of iron and steel, the "*minette*" (i.e., the ore of the Lorraine mines) takes a place of continually increasing importance; for this is the only ore which we can get out of our mines in continually increasing quantities. From sixty to eighty per cent. of our iron and steel is, at present, being made from the *minette*. If the production of the *minette* were interrupted, the war would be as good as lost.

There could be no plainer admission that modern war, when waged on a large scale, between antagonists of approximately equal power, is mainly a matter of metallurgy. But

a similar remark applies to the competition for foreign trade after the conclusion of peace. Stimulated by the demand created by the war, the productive capacity of this country has been enormously increased. The same thing has occurred, although not to so great an extent, in Great Britain, Canada, and France, while new Iron and Steel industries have been created or expanded in other countries, as in Australia, India, China, and Japan.

Iron and Steel After the War

After the war we shall find ourselves probably with an annual capacity of 35,000,000 to 40,000,000 tons of finished steel, and if the domestic consumption is not greater than its maximum in the past, it will leave probably 8,000,000 to 12,000,000 tons to find export markets; in other words, from 30 per cent. to 100 per cent. more than the present abnormal Steel exports, which are largely for war requirements.

England, with 8,000,000 tons before the war, will have 12,000,000 tons after it is over. The productive capacity of France and Germany must largely depend on the future of Lorraine and its ore deposits, as well as of the coal in the valley of the Sarre. The coal mines were acquired by Germany in 1815, and the iron mines in 1871. In the event of the retrocession of both to France, her annual production of iron ore would be raised to 43,000,000 tons, while that of Germany would be reduced to 8,000,000. In addition, France would have a new annual production of 16,000,000 tons of coal—an important addition to her capacity to develop her own iron and steel industries, instead of feeding those of Germany.

World Enterprises Following Proper Peace

Whatever the distribution of the European ore supply, it may be confidently asserted that our capacity after the war will represent nearly, if not quite, as much as that of all other steel-producing countries combined. We shall thus be as urgently in need of foreign markets for our products as the Germans ever were. But there would seem to be no

reason to apprehend the post-bellum "glut" of steel which some pessimistic observers have prophesied, at least during the first few years after the advent of peace. The destruction which has followed in the track of war has been so thorough and widespread, the depletion of existing stocks so complete, and the suspension of antecedent enterprises so much the rule, as to preclude any doubt about the steel-making capacities of the world during the period of rehabilitation being fully employed. The heavy demands on railroads from the extraordinary volume of traffic in recent years and the inadequate capacity of the steel mills of this country to meet these requirements, necessarily implies that an immense tonnage will be needed for repairs and new equipment as soon as the exigencies of war demands permit. In addition to all this, the regeneration of the ship-building industry in this country will continue to provide a tremendous outlet for steel, and the coming demand for structural shapes and other building materials may be partially gauged from the fact that building statistics show that new construction has been greatly curtailed as a result of the war requirements. The same statement applies to Europe as a whole no less than to the more progressive sections of other continents, and there can be little question that after the war the demand for steel will be sufficient to keep the industry on a stable basis for a considerable period.

As for the prospects of the more distant future, there is one point which cannot be too strongly insisted on, because it is frequently lost sight of, and that is the incalculable influence on the material development of the world of conditions of peace under which there will be equal opportunity for, and under which it will have been made safe for, commerce and industrial enterprise. Take the one item of railroad construction, which in two great continents—Asia and Africa—has been heretofore dominated not by commercial but by political considerations. After the peace, which we are all agreed in assuming will not be a German peace, no cloud will rest on the international status of such an enterprise as the Bagdad Railway. It will be one of the chief links in the great chain of overland routes

between Europe and Asia, stripped of all the perils to the world's peace that inheres in so-called "peaceful penetration." Its operation, as a purely business undertaking, will promote the construction of a network of railways in Persia; it will be linked with the Indian system on the one side and the completed Cape to Cairo line on the other. It will be a part of a great international highway that will draw closer the bonds between three continents and will cut in two the time consumed in traveling from Europe to Australia.

And this is but one of the great world enterprises to which a secure peace among nations, divested equally of the power and the desire to make war on each other, will bring a stimulus and support hitherto unattainable. It should be safe to predict that the ten years succeeding the conclusion of peace will be such an era of railroad construction as the world has not seen. And where the railroads go, into lands old and new, there will be created a demand for the utmost volume of manufactures in the service of an improved agriculture, of irrigation, of mining, of the utilization of water power, and of the processes of an expanded and diversified industry. No "glut" of steel should be apprehended in the saner, soberer, and chastened world which will emerge from the stern ordeal of the awful struggle by which it is now convulsed, because what we call the process of reconstruction will simply be the beginning of an unexampled development of the productive energy of the newly enfranchised nations.

Primary Requirements for Participation in Foreign Commerce

But it should be recognized that our share of this process will be small or great in proportion as we are able to coordinate our vast and varied productiveness to a common end. The necessity of balancing imports and stabilizing exchange; the creation of an American merchant marine, the necessity of compensating the output of additional capacity by increase of exports, and the advisability of meeting the combination of our competitors in foreign mar-

kets by the use of similar weapons, would seem to be among the rudimentary requirements of the situation. It is manifestly of the greatest importance, for example, that we maintain imports of necessities, such as manganese ore from Brazil, nitrates from the west coast of South America, pig tin from the Straits, wool, coffee, rubber and other commodities. These extensive and valuable imports must be balanced somehow, either by the maintenance of an export trade with these countries or in the familiar triangular fashion of equalizing them by exports to other countries which make the required payments to our creditors in goods of their own.

All of the European countries now at war will be under the most urgent necessity of exporting their products to the greatest possible extent as a means of rehabilitating exchange and of paying for needed imports. We may expect, as a consequence of the experience gained during the war, that the manufacturing nations of Europe will have learned the absolute necessity of organization, co-ordination and co-operation. If we are to meet them in foreign markets on terms of equality, it will be necessary not only that we establish methods of mutual co-operation, but that our government aid and protect us at least as effectively as our competitors will be aided and protected by their respective governments. In this connection the following report of the Committee of the British Iron and Steel Institute, on the re-organization of British Steel trade, is of interest:

> It is clear to the Committee that the one outstanding feature which has been revealed by their work, so far as it has gone, has been the eliciting of the almost unanimous opinion that if the steel industry in this country is to maintain its position, it must be by some great broadening of our commercial organizations that would lead to economies far and away outweighing any other element in the situation, and long ago realized and adopted by our foreign competitors. The view is held in trade circles that the industry can hardly hold its own in open competition with other steel-producing countries unless the contemplated scheme includes a central selling board under whose control orders would be allocated to the works in proportion to their capacity.

Our Need of a Merchant Marine

Our country has had to pay dearly for our abject submission to the decay of our merchant shipping in foreign trade. But the lesson has been learned and with it has come a recognition of these fundamental principles; we must be enabled to freight our products to foreign markets at a cost not exceeding that which will be available to our competitors, and this will be possible only if we have an American merchant marine unhampered by restrictions from which our chief competitors are free. The British shipping industry, which for generations has been and is still by far the greatest in the world, was built up by the exertions of the men engaged in it. It prospered because it was free from restrictions to which its competitors were subject. Theories to the contrary notwithstanding, we cannot have, in time of peace, an American merchant marine worthy of the name unless it be profitable to operate it without subsidy or subvention. This is manifestly not possible upon any practical or permanent basis so long as it costs more to operate an American steamer in ocean-going commerce than a foreign steamer in the same trade. Unsubsidized steamers have always been able to make a better showing for their owners than the subsidized ones, and it is certain that while a large majority of the British lines have received no subsidies from their Government, they have nevertheless grown and prospered, and have found no difficulty in competing with the subsidized lines. I repeat that what is necessary for the future growth and success of the American merchant marine is that it be placed upon a footing of equality with its chief competitors; with a fair field and no favor, repealing all laws which experience has shown to be detrimental to its growth, thereby leaving American enterprise free to achieve a success equal to that which the British shipping industry, unhampered by restrictive laws, has been able to accomplish.

The present plans of the United States Shipping Board, involving the building of millions of tons of ocean-going steamers, are not of greater consequence to the future of the export and import trade of the United States than they are

to the maintenance of the steel industry on that high plane of efficiency and maximum output which it has reached during the past year. There has been afforded, through the unexpected exigencies of this war, a hitherto undreamed of opportunity for governmental assistance in the upbuilding of a great merchant marine, as well as a striking illustration of the means by which American manufacturers can cooperate under government sanction and supervision for the supply of materials in enormous quantities. Idealized by the patriotism and loyalty which it has exemplified, we have had a close affiliation between the government and the great industrial activities of the country, the value of which in solving the special problems of the present, is of good augury for the service it may render in meeting the demands of the future.

Patriotic Services of American Iron and Steel Men

The American steel manufacturer has not only been called upon, in common with his fellow citizens, to yield a large proportion of his earnings in the form of taxes for the common weal, but he has ungrudgingly and voluntarily assented to the fixing of fair and reasonable prices much less than those dictated by the natural laws of supply and demand. This sacrifice has been willingly made in order that our government and its allies, as well as domestic consumers, may be able to procure the material they need at prices based upon costs with a fair margin of profit. Demands aggregating millions of tons have already been made upon these manufacturers, to which absolute priority has been and will continue to be given in the execution of orders. The fact cannot be too clearly recognized by the country as a whole that, thanks to the unexampled resources and efficiency of the steel industry and the unswerving loyalty and patriotism of its officers and employees, the one great factor in the successful conduct of the war, aside from men and money—that is, munitions of steel—will be provided in any quantity that may be required.

To this end the steel industry has cheerfully submitted

to the partial abandonment of its ordinary lines of manufacture and, consequently, of the exploitation of materials of special manufacture required solely for domestic consumption, as well as the abridgment of its regular export business and to interference with the natural supply of materials required for its regular domestic trade. It is co-operating vigorously with the War Trade Board in respect to export control of articles which it is desired to conserve for Allied or domestic use. It has voluntarily refrained, long before any embargo or license restrictions were imposed, from selling to neutral markets, at favorable prices, a much greater tonnage of steel which the world has demanded from us, because the industry realized the necessity of conserving a sufficient supply for the expected requirements for ships, for the Allies, for our railways and any domestic use essential to ultimate war purposes. It has released its ships, when they could possibly be spared, to the Shipping Board to aid in the transport of troops and munitions; it has since the outbreak of the war and long before regulations were established as to trading with persons suspected of enemy affiliations, scrupulously withheld from any commerce with them, which might conceivably benefit the enemy. All of this, and more, is the rightful contribution of the industry to the prosecution of the war for human freedom. But will it be considered as asking for more than its just rights if, when the war is over and it has to face the re-organization naturally attendant on a return to normal conditions, it should demand that it be reasonably protected—upheld and encouraged in its efforts at home and abroad to maintain its business on a basis of just prices and equitable returns? (Applause.)

President Gary: Discussion of this paper is now in order. (After a pause.) If there is no discussion, we will listen to some announcements by the Secretary.

After some announcements by the Secretary, the Institute adjourned, to meet in Dinner Session at seven o'clock, P. M.

SEMI-ANNUAL DINNER OF THE AMERICAN IRON AND STEEL INSTITUTE IN THE BALL-ROOM OF THE HOTEL SINTON, CINCINNATI, OHIO, ON FRIDAY EVENING, OCTOBER 25, 1917

EVENING SESSION

The usual banquet of the Institute was held on Friday evening, October 26, in the ballroom of the Hotel Sinton. The President of the Institute, Hon. Elbert H. Gary, acted as toastmaster.

After the banquet had been partaken of, the toastmaster called the meeting to order and said:

I have been furnished a program by the committee, as usual, and will follow that, perhaps not exactly in the order given but until it is finished, and after that, if I am requested, will call upon other speakers who may possibly respond to a call without previous notice. I think most of the speakers on the program have not had much opportunity to prepare, though I am not certain of that. Some have had a short notice. As the program is very long and correspondingly interesting, the Toastmaster will take no time, but will give all of the remaining time to the speakers. It is my pleasure to introduce the foremost citizen of Cincinnati, the Honorable Charles P. Taft. (Applause.)

Hon. Chas. P. Taft: Mr. President and Gentlemen of the American Iron and Steel Institute: I have had a little time to prepare, and what I am going to say, I have put on paper, and I propose to read it so that I will not digress too far.

This is a banner week for Cincinnati from the standpoint of patriotism, of industry and of education. I say of education because the Symphony Orchestra, a great educational force of our City, gave its first concert of the season this afternoon. From a patriotic standpoint, we rejoice in the success of our Second Liberty Loan subscription. A number of years ago, Cincinnati borrowed in London ten millions of dollars to begin the building of the Southern Railroad to Chattanooga. She paid interest at 7 3-10 per cent. per annum. It cost the city something over thirty millions of dollars to build the railroad. During the last two weeks, Cincinnati has been subscribing to the

Second Liberty Loan, and on Wednesday afternoon, she had turned over thirty-eight millions of dollars, three millions more than her maximum allotment. (Applause.) Formerly she borrowed ten millions on a 7 3-10 per cent. basis; now she loans to our country over thirty-eight millions on a four per cent. basis. I confess we did not quite understand our financial capacity until this exigency arose.

But, gentlemen, it was necessary to put the Liberty Loan behind us, before we could adequately and satisfactorily entertain the premier industrial organization of the world. (Applause.) You know, the men who do things here are the Cincinnati members of your Institute. We appreciate the fact that your Institute accepted their invitation to come to Cincinnati this year, and we will do what we can to make your visit a success. We have rather a warm feeling for the Cincinnatians who are members of your Institute. It is true, we cannot boast of great iron or steel works in our City. I notice that my friend, Mr. Meacham, to-day delivered an address before your organization upon the "Industries of Cincinnati." He might have enlarged upon the diversity of our manufacturing interests and described some of our factories, the largest of their kind in the country. We know that we have no place in Cincinnati for a blast furnace or a steel plant. What makes the iron and steel men popular here is the fact that, while they build their furnaces in Illinois, or Cleveland, or Buffalo, or the Hanging Rock region, or the Virginias, nothing has been able, up to the present time, to separate them from their home life in Cincinnati! (Applause.) They live here and are a part of the City's assets. I wish to extend to the Institute a cordial and hearty welcome to our City and to assure its members, that wherever they may go to-morrow they will find the latch string out and a generous hospitality awaiting them. (Applause.)

President Gary: I have the honor to introduce Mr. George M. Verity, of Middletown, Ohio. (Applause.)

Mr. George M. Verity: Mr. President and fellow members of the American Iron and Steel Institute: I feel it a great

honor to be here, as a member of the great Iron and Steel Institute of America. I feel it a still greater privilege to have the opportunity to speak for a moment to a group of men who are to-day such a large factor in shaping the destinies of the greatest liberty-loving people in all the world, if not of civilization itself.

When the chairman of the speakers' committee asked me if I would say something this evening, he telephoned me, and I asked him what he wanted me to talk about. He said, "Anything that you like,—anything that will amuse the audience!" Now, if he had just held the phone for a moment, and given me a chance to think, I would have told him that the only amusing thing I knew how to do was to play golf! (Laughter.) If any of you doubt that, I will challenge you to a game to-morrow afternoon! In going over my mail yesterday morning, I noticed one great large envelope on which was printed in large type, these words: "It is not what we work at but what we play at, that makes us what we are." That's one of the most discouraging statements I have ever heard, for if I and some of my friends in the steel business in this country, who are "dubs," are going to be the product of our golf game, I can only say, "Lord pity the product." (Laughter.)

As a member of the local committee, I want to express my appreciation of the magnificent attendance here in Cincinnati to-day at this Convention, considering the strenuousness of the times, and the fact that this meeting was held at the latter end of the week. I was more than surprised and pleased when I came down from Middletown this morning to find such a splendid attendance, and I am sure that it proves that the spirit of unity and co-operation, that our distinguished President has worked so hard and so ably to engender during the last few years, has been growing year by year, and I think you will agree with me that to-day it is a great national asset. (Applause.) I am sure that Cincinnati is proud to have this great Institute hold one of its regular meetings in its midst, and I feel certain that the good people of Cincinnati must have been influenced by the warmth of your friendship and the nearness of your presence

when they went over the top in such magnificent shape just a few days ago, in so largely over-subscribing their maximum quota in the second Liberty Loan. (Applause.)

No single group of men in all the world have a larger responsibility to their government or a greater opportunity to serve that Government and humanity than have this group of men here to-night. Iron and steel have become the very backbone of civilization, both in times of war and in times of peace. In war they are required for defense, and as an instrumentality to be used in every crusade for the maintenance of labor. And in peace the iron and steel furnaces, developed as those mills are, are the backbone of civilization. So should their makers be the very heart and soul of our modern society, known as Government. We should be the right hand to light the way of justice and mercy, and a tower of strength in the real progress of the world.

Our duty for the moment lies in production—more production, greater production—co-operation, service and sacrifice; and in all those things we can show the caliber and volume of our patriotism, and there are no more patriotic men in all the world than the men who are gathered here to-night. (Applause.) We have proved that on every occasion. We should leave nothing undone to uphold the hands of our Government.

In these days of trial, America's mission is to save the world during the war and to help make it safe from savagery. After the war, the stars and stripes must represent the world, industrially, commercially, financially, and in ideals and accomplishment, and in fact, everything that makes life worth while. No more serious situation ever existed in the history of the world, no greater task was ever to be performed. It may take three months; it may take three years. But, tremendous as are the problems involved with civilization itself in the balance, I know you feel as I do that we are fighting because we know we are right; and that once drawn in the cause of liberty, America has never sheathed the sword, except in victory, and we shall see it through to the end, cost what it may! (Applause.)

The Kaiser informed us through our accredited representative that he would take no nonsense from us after the war. Our subscription to the Liberty Loan, our hearty, prompt, and generous response to all the things that have been asked of us by our Government, is our answer to the Kaiser, that great High Priest of Evil, and to his sniveling, cowardly accomplices, who, to accomplish their dastardly acts, would destroy the womanhood, the motherhood, and the childhood of the world, that we will give them all the nonsense they want during the war, and that after the war, there will be no Kaiser to menace the peace of the world! (Applause.)

As serious as is the task in hand, it seems to me that we must find time to give earnest thought to the subject, "After the war, what?" Three years are a short time in the span of life, but not in the face of all time; and I feel we should, even at this early date, be giving much thought to the conditions under which we must live and work after the great war is over. We shall find ourselves living in a new world, under absolutely new and changed conditions. The old order of things will have passed away, and we must face the new order. As great as are the problems of the world war, I believe that those to be solved after the war will be even greater. To my mind, the great problem we will have to meet after the war, when re-adjustment comes and re-construction follows, will be to make ourselves as efficient, industrially and commercially and in every other way, as any other nation in the world, because I believe the race in the commerce of the future is going to be to the efficient. It has only been a short time since France sent a commission here to investigate our industrial conditions and to determine what she could do to make her factories more efficient after the war. In Germany they have given much thought to what they were going to be doing after the war. Engaged though they are in a struggle to the death, they are giving thought to that question every day. It is within our power and it is a part of our responsibility to live in the commerce and finance of the world after the war.

Now, what can we of America do to accomplish that end?

Can we give it less thought than those nations who are struggling so much harder than we are to-night? I feel that it is up to us to be looking ahead. No nation and no industry can live without vision, and we must be looking ahead to see what is coming to us.

After the war, I believe that this great steel industry will not only lead the world as steel manufacturers, but we should lead the world in creating stable industrial conditions; we should, if possible, solve the problems between employer and employee. Much has been done by many industries in this great business. The great corporation of which our President is the head has done possibly more than any other business organization in the world to bring about satisfactory and permanent industrial conditions. There are many of us who feel that we have accomplished something in our several communities, and that we have a sound industrial condition; but gentlemen, we want community of effort along those lines. And the concern that feels that they can build up merely locally such industrial conditions as will protect them from the troubles of the dissatisfied, are simply patterning after the ostrich that sticks his head in the sands. We are bound to be influenced and affected by the general conditions through the country. So that I am as much interested in the conditions in your works as you are interested in the conditions in my works. And we ought to see to it together that at this stage of the game and in the great development we have made in all these things in America, we come together and talk over frankly and fully what has been accomplished by our various parts and send our conclusions out in the form of a report, so that all of the industries can use it. We ought to sit down and figure out what more we can do to stabilize labor and all industrial conditions, to the end that we may secure that efficiency that will enable us to lead in working out the destinies of this great country. We must be giving thought to all those questions; they should have their proportion of thought on the part of all the members of the Institute. In the meantime we must leave nothing undone to help bring back victorious the flag that we have sent across the

water; and not only to bring it back in victory, but to bring it back at the earliest possible day! (Applause.)

President Gary: I now present our old friend, Captain Robert W. Hunt, of Chicago. (Applause.)

Captain R. W. Hunt (standing on a chair): Mr. President, Ladies and Gentlemen: Excuse me for "taking the chair." But I am reminded of an incident which happened in the life of a fellow Chicago townsman, Mr. James Scott, when he was presented to the Clover Club of Philadelphia, which, as you will recall, is noted for the hearty reception it gives to those gentlemen who are presented at its dinners. Mr. Scott's stature was certainly no greater than mine—perhaps not quite so great. When he stood up and attempted to reply, the general exclamation went over the room, "Stand up, Mr. Scott!" "Mr. Scott, why don't you stand up?" So, I thought, at least, I would deprive you of the opportunity of sending that shaft at me. (Laughter.)

But seriously, gentlemen, I am very much honored, as my friend, Mr. Butler, would join me in saying, to have this opportunity of speaking to "my boys," and it certainly makes us proud to know that that industry in which we have spent the best part of our lives is now represented by the class of men who are here to-night. No wonder that this country leads the world in that industry. It could not be otherwise. And to-day, Mr. President, as I was listening to your patriotic address and to those patriotic sentiments expressed by those who listened to you, I was reminded of the old historic incident that dates back to the War of the Rebellion, which perhaps may be known to some of you, but by others, perhaps, it may have been forgotten. You will recall the devastation that was created among the choice ships of our navy, in Hampton Roads, by the Merrimac. After the destruction of those great vessels, the further bombardment of our scattered cities by the Merrimac was halted by the unexpected presence of the Monitor. Perhaps you do not know that at the time the Monitor fought that battle, she was not the property of the National Government. The naval authorities of those days could not be

convinced of the soundness of Captain Ericsson's idea of an armed vessel and a revolving turret, and declined to sanction or to furnish the funds for the construction of such a vessel. It fell to the patriotic devotion of two iron masters, John A. Griswold and John F. Winslow, of Troy, New York, to advance the money for the construction of that boat. And, while William Bigelow, of Providence, Rhode Island, perhaps joined, those two, John A. Griswold and John F. Winslow, were the men that really furnished the money. (Applause.) And it was in the rolling mills of John F. Winslow & Company in Troy that the iron plates which entered into the construction of that vessel were rolled and fabricated. When she reached Hampton Roads, unaware of the threatened danger from the Merrimac, she was on her trial trip. So that, when she entered into the battle the next day, the officers, Commander Warden and his gallant assistants, and the crew, too, took their lives in their hands, so far as they knew, to fight that experiment against that already demonstrated destructive monster, as she was then regarded, the Merrimac. And there, as I am trying to point out, the lesson was the same spirit of patriotism made manifest and bringing great results to our country that you gentlemen pledged yourselves to to-day. (Applause.)

I am very much disturbed, as you are, on the labor question. We are sending thousands of men abroad. We are enlisting in many war occupations thousands of others, and we may expect that other hundreds of thousands will be called to war duties. We are urging, at the same time, that it is the patriotic duty, and the necessity, that this country should increase her acreage of agricultural products. Now, as many farmers have expressed it to me, what's the use of our increasing our acreage of wheat if we cannot reap it? What's the use of increasing our acreage of corn if we cannot cultivate it, and afterwards harvest it? In fact, I know of instances of large owners, and one in particular who this year had fourteen hundred acres in wheat and twelve hundred acres in corn. It happened that in the section where he has his holdings, that the weather conditions were such that his wheat practically came to naught, but his corn

gave a bounteous yield. But he said, "Based on my experience with the difficulties of obtaining labor, I cannot see my way clear to plant now within twenty-five or thirty percent of the acreage that I did last year." I find that this is the feeling throughout the great Northwest, where the great bulk of this harvest must come from. Now, what are we going to do about it? Where is that labor to come from? It strikes me as perfectly practicable for this Government, as a war measure—and this thought was enforced upon me when Mr. Hobson spoke this morning of having seen those Chinese coolies going to France to labor behind the lines—it seems to me to be perfectly practicable for this Government to enter into a treaty with China, who has pledged herself on the side of the Allies, to bring to this country the necessary number of coolies to be distributed by the Government and under Governmental control, throughout the great agricultural regions of the country. Let it be done on this plan: The farmer shall pay to the Government the same wages that he would have to pay for white labor, and the difference between that paid the coolie and received from the farmer, shall go into the war fund of the nation. It seems to me that that would eliminate, or should eliminate, the opposition of the trade unions—and when I say "trade unions," I am speaking of patriotic, legitimate workmen's organizations; I do not refer at all to the I. W. W.'s, because the place for them is in the trenches, on the gibbet, or before a firing squad! (Applause.) I believe that the proposed plan would require an act of Congress, that the Government now could not bring it about under the Alien Laws; but certainly, if the idea is right, Congress should see it and will see it. If we don't pursue some such plan, what is the alternative? We must have help, if this war goes on, to reap the harvests of that which we have planted.

This war is THE topic. This war and the successful prosecution of the war is the one great over-shadowing duty which has presented itself to every American citizen. This war of which it is impossible to speak and use temperate language, this war which has violated every sanctified feeling or principle of humanity, must be won. But we must

remember that Jehovah has proclaimed that "Vengeance is mine, saith the Lord." And, as sure as the Lord God Almighty exists, vengeance is coming! nay, vengeance is here! You can't tell me that the heads who are responsible for outrages which cannot be described, can rest content and sleep the sleep of the tired. Oh! the wraiths and the spirits of the murdered ones must be hovering around those pillows to-night and bringing already the punishment and vengeance of the Lord.

Some have said, and even some good mothers and good fathers have felt, "Oh! that our boys were to fight on this soil; but to send them abroad, to send them to France is the hardship." But I say to you fathers, and you brothers, and you mothers and you sisters, you ought to thank God that your dear ones are going to France to fight! (Applause.) We know now by the developments that if it had not been for noble Belgium, gallant France, and chivalrous England, the German horde would have been upon us through Canada. They would not have approached us through those guns protecting those coast defenses, of which we are so proud, but rather, they would have approached us from that frontier upon which there isn't a gun nor a fort, and thank God for it! And I hope there never will be! Or from our southern boundary through Mexico, almost equally unprotected. And then those scenes of outrage in Alsace and Lorraine and in Belgium would have been enacted upon this soil. And so, thank God, you women, that you are spared that which your sisters were forced to bear.

It is with hesitation that one dares to commit himself to my next thought, let alone utter it; but still, as a patriot, I do hope that the war may not end, and God knows I want to see it over, but I hope it will not end until our men have had a chance to shoot, until they have gone over the top. (Applause.) If blood is shed it will have been shed upon the altar of patriotism and it will prove that we are a nation of freemen, that our flag is the flag of humanity, the flag of democracy, and that it stands for those virtues which we have claimed for it and that we are worthy to have it. (Applause.)

President Gary: All will remember with pleasure our visit to St. Louis for the semi-annual meeting of 1916, and you also know that on that occasion Mr. Clarence H. Howard, the President of the Commonwealth Steel Company, so far as the entertainment, reception, and the generous hospitality were concerned, was the leading spirit. Now, gentlemen, it is my pleasure to call on Mr. Howard. (Applause.)

Mr. Clarence H. Howard: Mr. President, and Gentlemen and Ladies: I am very happy to have the opportunity of being here to see those with whom I formed such fine, enjoyable acquaintance and lasting friendship at St. Louis a year ago.

Many things have occurred since we were in St. Louis; since then we have entered the great war. I want to say a thing that came to me this morning while I listened to the splendid address of our beloved President. It was said that the steel world was prepared and ready. Let's analyze that and see why. There was a time when it was said that competition was the life of trade. Then our President, Judge Gary, announced that that was not true, that co-operation was the life of trade and the safety of our American institutions. And through that idea this Institute, and these meetings, came that preparedness to take charge of the important duty that the steel world has to-day to our brothers across the water. Had we been in that old form of competitive war, we would not have been prepared. But in union there is strength, and in discord weakness. These meetings have brought about this wonderful state of affairs in this country. For this we should always be very grateful to the man who has so led us into lines of better ways, the man who sees the best in every man, the best in every business and the best in his nation, and that's what we must all do.

Now, how about the railroads? Let's think about them for a moment. They are the arteries of commerce, and they give value and potency and force to that which is produced, because of their ability to transport it from the

place of its production to the place where it is needed. Have we been as good to them as we should? On the one hand we say they may charge only so much for rates; on the other hand we legislate that certain employees shall have higher wages. Certain states have pushed on them this sort of thing, and to-day they are paying three times as much for their locomotives and cars as they formerly paid, and that means they must charge off three times as much when their power is worn out. Now, they can't do that unless we give them enough to perform the functions which they are intended to perform. I want to say that I believe the public are more to blame than anybody else. What would we do if our prices were restricted and everything else was raised, when the end of the month came and we didn't have enough to pay our bills? Who wants to buy securities issued by railroads under present conditions? And, without the railroads, there would be no successful operation of business either in times of peace or in time of war. We must have them; we couldn't operate twenty-four hours without the railroads. We have got to have sufficient equipment so that we can get our goods to each other, so that we can get our material to the shipbuilders, so that we can get our food, not only to our own people, but to our people across the water. So, I believe the time has come when we must be more liberal with the railroads and help them out as much as we can. (Applause.)

It may be that some wrongs have been done in the past, but we can't talk about the past when we are in the middle of the river. We have got to find out how we can best get out of this situation just now. I think that's one of the problems on which the success of the war depends, as well as the success of your business and of my business. And we ought to be willing, from the prices and the profits that are coming to the world at large, to say that these arteries of commerce which have so much potency for good shall have full and ample protection, as they join with us and with others in the great effort to win the war. The time has come when we must face this problem. (Applause.)

I have just received word from the Scout Boys of St.

Louis, of whose local organization I am President, that they have turned the three million point in their Liberty Loan subscriptions. When boys can do that kind of work we have something to be thankful for in our boys. A boy has one hundred and fifty pounds of available steam, and if he don't work with you he will work against you. Let's keep them in constructive work, such as this and other activities.

I am very happy, indeed, to be here to-day with you, and I hope that the time may come when our good President and the Board of Directors will wish to return to St. Louis, so that we may have the pleasure of having you with us again. (Applause.)

President Gary: One of the most notable members of Congress is the Honorable Nicholas Longworth, of Cincinnati. We always know where he stands, and that he is on the right side. I now have the honor to introduce him as the next speaker.

Hon. Nicholas Longworth: Mr. President, Captains of the Iron and Steel Industry, Ladies and Gentlemen: I assure you that I highly appreciate the honor of being here on this most interesting occasion. I greatly appreciate the honor of having been asked by your committee to say a word. I asked your committee what they suggested that I should say, and they replied that they hoped I would say a brief word of welcome. It struck me at the time, and it strikes me now, that there is some little irony in having a word of welcome said to the iron and steel industry of this country by a member of the Ways and Means Committee of the last Congress. (Laughter.)

I do rejoice, however, that in another capacity, as a citizen of Cincinnati, I can bid you a word of welcome to the city that I was never so proud of as I am to-night, since I heard that Cincinnati was the first of the great cities of this country to pass her maximum allotment for the Liberty Loan! (Applause.)

But, as a matter of fact, both as a Cincinnatian and as a member of the Ways and Means Committee, I bid the iron and steel industry a most hearty welcome. You are

probably the most fruitful and voluminous field for taxation that we could find! (Laughter.) But this I can say, and I say it because I know, that of all the industries taxed under the last revenue bill, you made less complaint, and you stepped forward in a more patriotic way, than any other industry in this country. (Applause.) You are broad-minded men, you are men who see far ahead, and you realize that in a case like this, in a case where the very existence of this nation is trembling in the balance, that it is for those who can, to step forward, pay their taxes, and subscribe to the loans of this country, without a selfish thought. And you have done it, and I am proud to be here and face the men of whom I can say that.

The outstanding feature of this last session of Congress has been, and I suppose it has been the same way in your industry in these times of stress, that we hardly knew from one day to the next what was going to happen. When this extra session of Congress assembled we were told by the responsible officials of this government that the war expenses for this year would be in the great sum of four billion dollars. And the program was that we should issue two billion dollars worth of bonds and raise a billion and eight hundred millions by taxation, the theory being at that time that this war should be financed on a "fifty-fifty" basis—that the present generation should bear half and future generations half. I followed along on that proposition temporarily, though I have reserved the right, and I do now, to do all I can to finance this war on a very different basis. I don't believe that the expenses of this war should be borne by this present generation, and by the business of this country, to the extent of more than twenty-five per cent. But I believed then—to use a common expression, I had a "hunch" —that the expenses were going to be more than four billion dollars. And so we proceeded day by day, and in a week or two they raised the estimate to five billion, and then to six and then to eight, and then to ten, and before we got through last week the amount appropriated in this session of Congress for war expenditures was the astounding total of twenty-one billion and five hundred million dollars. That's

hard for even you gentlemen to understand! It is hard for the great financiers of your largest corporations to understand, although the United States Steel Corporation was the first corporation in this country to make a billion dollars "famous." Why, you are "pikers!" (Laughter.)

We have appropriated twenty-one billion five hundred million dollars in the last eight months! May I give you a brief illustration of what that means, because I don't intend to bother you with figures, and I am going to be very brief. It is more than twenty times the national debt of this country before the war started. It is more than twenty times as much as any other session of Congress ever appropriated in all the history of this country. It is more than four times as much as our total national debt—the debt of every State, of every County, of every City, of every Village, and of every township in the United States. It is as much as the entire war expenditures of the German Government, including their loans to Turkey and Bulgaria. It is as much, nearly, as the total expenditures of Great Britain for this war. It is more than the total war expenses, a great deal more, than the total war expenditures of France or Austria or Russia. I am not here to say a word of criticism of any party, or of any individual in this nation. I don't say why these expenditures are so tremendous, except this, that if we had had the sense as a Government to make reasonable preparation for what any far-seeing man could tell was going to happen, our expenditures would have been infinitely less. (Applause.)

But whether that is true or not, it is all the more up to us to pay these expenses, whether they be great or small. (Applause.) There are only two ways in which this Government can raise these expenditures. One is by taxation; the other by loans. It is true that of this tremendous sum of twenty-one billions and a half, seven billion dollars represents loans to the Allies, and it is possible that we may need only a portion of that in this year. It is true, also, that about two billions and a half represents contracts for supplies of various kinds that have been authorized by Congress, and it is possible that all of that may not be needed.

But assuming that not a cent of it is needed, we have got to raise twelve billion dollars before the first of next July. Many men have asked me since I came home a week ago whether any estimates had been made about our war expenditures next year. Now, manifestly, that question is absolutely impossible of answer. We can't tell. And this is the thing we must think of when we are considering how we are going to finance this war: we can't, of course, tell how much more money our Allies will need, and the amount we give to our Allies is just as necessary as the amount we give to ourselves. Where would we be if it wasn't for Great Britain's fleet to-day? Where would we be if we were not practically dependent on France and Great Britain to protect our lives? And so, I say, our loans to our Allies must be given freely and we must not stint. So, of course, those are things we cannot tell about. As I have already indicated, many things have happened, many things turned up from one day to another; and of course, we can't tell what may eventuate. This, however, I think, can be fairly said, that a great deal of the money that has been appropriated this year, has been appropriated with more foresight than usual, much of which will be in the nature of permanent improvements, and we won't have to spend any more money for those things. Generally speaking, we have appropriated for an army of two million men. Of course, we have nothing like that now, and a large part of that expenditure ought to last us for some years. This would include our expenditure for ships and for ammunition and for guns, which we were absolutely without. We can't tell, however, what those expenditures will be. But I say this to you, my friends, if I can at all interpret the spirit of the American Congress of all parties, democrats and republicans, that we are preparing for a war of length, and we propose to keep on furnishing men and money, regardless of cost, to the end that this war shall be concluded in honor to the United States! (Applause.) And that it shall be concluded with a peace, not a sporadic peace, which doesn't mean anything, but the permanent peace of the world! (Applause.)

I sincerely trust that in our financing of this program—

and I am very hopeful when I see how the American people are responding to the demand for these loans—that we shall not be forced to exact money from the American people, but that we will get the bulk of it by simply asking for it. Just a word of digression, a figure or two that some of you may not know, as to the method in which the belligerent Governments have financed their war expenses so far. On the basis that I have indicated to you of our present revenues, including the law just passed and the amount necessary to raise, from thirteen to fourteen billion dollars, we are going to raise in the next year somewhere between thirty and thirty-five percent by taxation and somewhere between sixty-five and seventy percent by loans. Now, even that is a far greater taxation program than that of any of the belligerent nations of Europe. Great Britain has financed her war, so far, not to exceed twenty-five percent by taxation. I believe that that is the fair thing for America. But Great Britain has raised more taxes than any other country. I won't attempt to give you the exact figures, but these are approximately correct. France has financed her war not to exceed fifteen percent by taxation; Germany about fourteen percent; Italy somewhere about twelve percent; Austria even a little less. Our neighbor on the north, Canada, only eight percent; and so far as we can hear, Russia practically nothing by taxation. It only shows that this country ought to be able to finance this war, without passing in the near future another bill for taxation, which I fear will greatly over-burden American industry. I am greatly in hopes that that will not be necessary, but whatever may be necessary, my friends, we have got to do. You will agree with me when I say with all the force and conviction that are in me, that being in this war now, being in it up to our necks, we cannot afford to lose, and for those of us who stay at home, our duty is clear. This country from the beginning has been free and unconquered; it is the duty of all of us together to see to it that in this war, she remains forever free and unconquered! (Applause.)

President Gary: This very able and forcible address appeals to our intelligence and our judgment. We know

that in Congress we have a representative who will present these economic questions with great skill and ability, and that, so far as possible when his party is in the minority, our interests will be protected. No doubt the business men of this country have more or less been subject to unfair treatment; their rights, business, and property have not always been fully protected. But, so far as we who are members of this Institute are concerned, we can afford to forget it. There has been no intention on the part of the distinguished gentleman to raise in our minds any spirit of antagonism to the work which is going on, but there is some danger that his mere reference to facts may produce in our minds a feeling that at this time we should guard against. The Liberty Loan is a splendid thing. There has been released from the minds and souls of men, feelings of patriotism, and of generosity, and of pride in our country. We heretofore have been too selfish; we have paid too much attention to our business; we have forgotten, or at least neglected, our duty and our obligations. To-day the thoughts of men and of women are focused upon the necessities of our National Government. Men and women all around us are making sacrifices. They propose to lay everything upon the altar of sacrifice, so far as necessary to protect our flag. And when to-day, at the request of your President, every man stood upon his feet and pledged himself that he would devote his time and his energy and his money to the glorious cause of liberty, I felt proud of you. We may be proud of this country and of the men, and especially of the women of to-day, and of what is being done. And when the opportunity is given to the women of this country to go to the ballot box and put in a vote for the cause of righteousness and of liberty and of patriotism, then we may expect something a good deal nearer the millennium than anything we have before experienced. (Applause.) We will now hear from Mr. Harry C. Busch, of the Cincinnati Iron and Steel Company.

Mr. Harry C. Busch: Mr. President and Gentlemen:

"When the Lord Mayor comes around,
Provincials stand in silence profound."

These lines went through my mind this morning after we had heard that able, clear cut, timely, and well phrased address of your President, Judge Gary. And then there recurred to my mind a paraphrase of the words of Kipling: "Yes, he is a man who can hold his head when others lose theirs; he is a man who can trust himself when others doubt; he is a man who can walk with kings and still keep the common touch; he is a man who would not bend his stubborn knee except to commercial chivalry." Hearing so much these days about taxation, especially from my worthy friend, Mr. Longworth, I hope that, after it is all over and we get through with taxation and Government commandeering and control and all that sort of thing, we will not find the steel industry in the condition of the heroine in the show entitled, "Nellie, the Beautiful Cloak Model." In the first act, the villain threw her off the Brooklyn bridge; in the second act, she was thrown off the deck of an Atlantic liner; in the third act, she was thrown under the elevator; and in the fourth act, he looked at her pathetically and said, "Nellie, Nellie, why do you fear me?" (Laughter.)

My friend Longworth has perhaps heard the story told by Senator John Sharp Williams at a dinner at Columbus, Ohio, some weeks ago. Some one turned to him and asked what Congress was doing. He replied, I can best answer your question by telling you a little story. There was a negro preacher down our way, and he lost his job. He met a friend on the street and was telling him his troubles and the friend asked him, How did you lose your job? Well, he said, I went to the trustees and said, "Now, trustees, haven't I taken care of all the sister'n?" "Yes." "Haven't I been good to all the brethren of the church?" "Yes." "Haven't I argufied the Scriptures on Sunday?" The trustees said, "Yes, you have taken care of the sister'n, you have been good to all the brethren, and you argufied the Scriptures all right, but you dun get nowhere." (Laughter.) Whether that is a true definition of Congress, I won't say. Sometimes it seems so. I often think of old ex-Speaker Tom Reed's definition of a statesman, when he said, "A statesman is a politician who is dead."

But speaking seriously, my friends, in this great hour of national stress, when the words of Robert Burns, "Man's inhumanity to man makes countless thousands mourn" are driven home to us, we look to you, Judge Gary, and your friends, and say to you, "Have no fear of this community. For we have long since recognized the keynote of your speech, in that we know and feel that the motive power, the driving power behind all American energy, must, after all, be the patriotic American heart." And we say to you, that we have freely given, and will continue to give, our best blood in the nation's defense. We have gladly poured out our treasure for the rebirth of America's spirit of freedom and liberty. And not only will we do that at the call of the Government, but at the call of you men who hold the commercial destinies of this country in your hands and under whose leadership we are proud to enlist. And under your banner, aided by our little help, we will build up a steel wall, an unyielding steel wall, in the path of Germany that will soon end this war. (Applause.)

President Gary: Mr. Frank Billings, of Cleveland, will now favor us.

Mr. Frank Billings: Mr. President and Ladies and Gentlemen of the Institute: About a century and a quarter ago, during the debate on the first tariff bill after the adoption of the Constitution, I believe it is recorded that a gentleman from Connecticut arose and said, when they came to the iron and steel schedule, "Now, there's something we never can make enough of to satisfy the demand, and therefore, there should be no duty charged upon iron and steel, and those products should go on the free list." Whereupon a gentleman from Pennsylvania got up and said, "That isn't so, because there's a furnace in our state that last year made two hundred tons of pig iron and I believe this year will make two hundred and fifty tons"; and on that statement a tariff was put upon iron and steel! (Laughter.) From that day to this, the iron and steel industry has progressed and developed, until, as you know, in the year 1916, the production of pig iron was more than thirty-nine million

tons, and many furnaces made over twice as much in one day as that little Pennsylvania furnace made in the whole year.

The production of steel ingots, as you know, was about forty-one million tons. Of the part the Mesaba Iron Range has played in this tremendous production I will not speak, but only to call your attention to the fact that the first shipment from that range was made in the year 1892 and the production for that year was a little more than four thousand tons. Of the total production of the iron ore district of Lake Superior in 1916, of something over sixty-six million tons, the Mesaba range produced over forty-two million tons.

Whether or not this rapid and gigantic development of the iron and steel industry, with its consequent depletion of our mineral resources, is of lasting benefit to this country the future will disclose; but we know to-day that in the magnitude of its production and in the splendor of its achievements, it is the most potent factor in the saving of democracy and the liberties of the people for the nations of the world. (Applause.) From the first, this development has been governed by the great, fundamental law of supply and demand, modified to some extend, during most of the time, by a reasonable protective tariff. There have been low tariffs and there have been high tariffs; there have been lean years and there have been prosperous years. But through it all there has been one noticeable characteristic of the Yankee ironmaster, so-called, which has always been in evidence and I believe is still in evidence, and that is, when times were bad and the supply was greater than the demand, and he was running part time or no time at all, he fully believed that the times never would grow better again, and that the country was "going to the dogs!" But, when the prosperous times came and the demand was greater than the supply, he girded up his loins, put most of his profits back into his business, borrowed all the money he could, and promptly duplicated his production. (Laughter and applause.)

To-day the great law of supply and demand is not working freely. "Grim visaged war" stalks abroad in the world,

and the unprecedented demand for iron and steel grows out of the necessities of that most awful conflict. This is no time to carry out the usual plan, and to increase capacity for the production of more pig iron, or raw steel, for the reason that the demand is greater than the supply; but we should bend all our energies in the getting to the furnaces of the raw materials and getting the fabricated products delivered to the purchasers. Those of us who are shipping iron ore from the Lake Superior districts and coal to the same districts and the Northwestern country, have a big problem, inasmuch as we have to deliver during the season of the Great Lakes navigation—a period of not over seven months, and this year considerably less than that—the tonnage requirements for the whole year. The traffic on the railroads seems to be to the limit of their capacity, especially in that territory which serves the inland furnaces from the lower lake ports. There's a crying need for munitions and ships and implements of war; but we know there is also a crying need for open-top cars, and the locomotives to haul them, in order to utilize to the fullest extent and magnify the capacity of our mills and furnaces already in operation. There have been organized in Cleveland two bureaus or exchanges, one for expediting the shipment of iron ore down the lakes to the lake front and inland furnaces, and the other to expedite the shipment of coal from the lower lake ports to the great Northwest. Those two bureaus or exchanges have been operating very successfully, and through their operations, I believe, sufficient iron ore will be brought down the lakes and delivered to the inland furnaces and on the docks, at lower lake ports, to fill the requirements of the furnaces until the opening of navigation next year. These bureaus or exchanges are operating under two great principles, and I believe they are the same principles underlying and governing this great Iron and Steel Institute and of which our President is such a notable disciple; namely, co-operation and fair play. To-day, co-operation and fair play are the beacon lights showing the way to prosperity and happiness, not only in the life of the business man and the citizen, but in the larger sense, in the life of a govern-

ment "of the people, by the people, and for the people," in the international life of all the Allies, who are fighting for the cause of democracy and liberty throughout the world! (Applause.)

President Gary: I will now call epon Mr. Robert W. Campbell, of Chicago.

Mr. Robert W. Campbell: Mr. President, Ladies and Gentlemen: I think none of us can have sat through the meetings of to-day without feeling that there was a spirit permeating them through and through. That spirit was the spirit of patriotism, which has found expression here on every side this evening.

Patriotism is one of man's remarkable qualities, and it finds expression in many different ways. There's one kind of patriotism of which we haven't seen much in the present day, that patriotism that finds expression in selfish wallowing in the trough of the public treasury, or in selfish consideration only of private gain. But it is not of that kind of patriotism that I would speak this evening. I have in mind that true patriotism, that patriot who, by unselfish loyalty and devotion to his country's needs and through organized activity and individual service, makes possible the highest achievement of his country's aims and purposes. Having that in mind, I feel that we, as members of the American Iron and Steel Institute, might have much that we could consider ourselves proud of to-night. We might be proud of the part we are playing in this great conflict. However regrettable it may be, it is here, and we are in it, and we should be proud that we are in it; for wherever has waved the banner of liberty, justice, right and equality, there is and should wave the stars and stripes. (Applause.) We have shown to the world that we have taken our stand for right, for justice, for civilization, and for democracy in its struggle against barbarism and inhumanity and laws of class and autocracy, and even the slavery of nation to nation. We have given the lie to the allegation that has often been made, that America and its industries had no thought for anyone other than self, and that loving wealth we loved not

honor; and we should be proud to-day, as American citizens, that we have placed ourselves on the side of honor and freedom and are standing for the spirit of democracy in the world.

We may be proud, also, of our national achievements since the beginning of the war. A bare six months have elapsed and yet our nation is completely organized. Our troops are upon French soil; our navy is in foreign waters; and already a new army of immense proportions is in training. Socially and economically our lives have been reorganized to meet the new requirements; and politically, economically and socially, we are prepared. No matter whether we may or may not feel satisfied with each and every element of that program, yet, on the whole, it is so constructed as to merit approval and even pride.

We might also well be proud of the part that our organization has taken, not only as an organization but also through the individual industrial units that it represents, in the accomplishments that have gone forward in the past few months. There is no other industry that occupies so important a position with reference to the present needs of our country. It is the bulwark upon which, in the last analysis, rests the safety of our country, and you who have measured up to your responsibilities know, as well as do I, that we have met the Government fairly and squarely, and even generously, at every point; we have co-operated when and wherever opportunity has afforded. You have done even more. You have, as has been testified here to-day, practically turned over your plants to Government work, sacrificing the gain of private business to the public needs.

Your attitude toward your employees is likewise worthy of comment. You stand to-day in the vanguard in this industrial field, having the interests and welfare of your employees at heart; and to-day, when the human resources of our country are so important, you are doing a work that has never been thought of before in the extent to which you have gone in providing safety for your men.

We might also be proud of the individuals of our organizations. Personally, you have given your sons, you have

given your brothers and those who are dear to you. Your mothers, your wives, and your daughters are working for the public good, and each one of you is to-day giving of your time, of your energy, and of your money generously and without stint along some of the organized lines of activity, either national or local, governmental or private. You are all engaged in work for the public welfare, and gentlemen, of all those things, we may well be proud.

On a recent French anniversary, General Pershing made a brief but memorable address, when he said, in laying his wreath of tribute upon the tomb of LaFayette, "Well, LaFayette, we are here." Gentlemen, you have been in the past and you will be in the future, I know, true to yourselves, true to your country and to its cause, and you will continue to say to-morrow, as you have said to-day, and as you have said in the past, "We are here." And so, Mr. President, if I may be permitted, I give a toast, "The American Iron and Steel Institute, a true patriot!" (Applause.)

President Gary: I will now introduce Mr. James H. Dempsey, of Cleveland, Ohio.

Mr. James H. Dempsey: Mr. President and Gentlemen: It is too late for me to inflict upon you the numerous things which I thought might have interested you this evening; therefore, I will content myself with just a few words.

As I have been sitting here this evening, listening to what has been so interestingly said and seeing this banquet progress, I have been reminded of the time, three years ago, when there visited this country from Germany a commission of savants and professors and eminent business men, coming under the guise of our great friends. They were entertained here, by reason of the friendships they had formed before they came here. They were given introductions from place to place in the various cities of this country, and every expression from them that I have heard of was along just one line: "We are here to foster the friendship and good feeling, that has always prevailed between Germany and America. Our aim is to keep you from getting interested in our opponents, so that when the conflict comes

America alone, will be the great neutral power to arbitrate and settle the differences between us." So far as I know, this was all accepted in good faith.

It should have been in good faith and we had a right to believe that it was in good faith. But subsequent events would challenge the good faith of those statements. Shortly afterwards, when we were in a disturbed situation with Mexico, we have every reason to believe that, through German influence, aid and comfort was afforded to what were then our enemies on our Mexican frontier. Later on, the attempt was made to induce Japan to become an enemy of this country. And later on, we know how active they were within our own borders in fomenting trouble among the useless, worthless, and abominable I. W. W.'s; and their efforts were even extended to our negroes in the south. All of those things, of course, in the end, have proven futile, but they have demonstrated that the Commission sent here at that time were not acting in good faith, as we supposed they were.

Now, there is just one thing that I think hasn't been, perhaps, sufficiently touched upon here to-night. We are patriots. Everyone of you here has shown your patriotism. You have stood up in every respect. You stood up to-day and pledged yourselves to do everything in your power, and not only have you stood up here and by your efforts and your loyalty to this Government at the present time of stress, but you are standing up by sending to Europe the one commodity needed more than anything else, and in a greater amount than any other nation could or would furnish it. So that to the steel men of America the greatest respect is due, not only for what they have done but for what they are going to do to the end. The Kaiser claims to rule by charter of divine right from the Almighty. We resent that sort of thing; there can be no such thing as divine right in the Kaiser; that's the thing that we must stop, and that's going to be stopped. The transcendentalism of the old monarchical form of government is offensive and obnoxious to the American idea, and until it is wiped out America is not going to be satisfied. It was not origi-

nally our fight; they have made it our fight. They have attacked our shipping; they have attacked our people; they have betrayed our confidence both within and without our domain. They have brought home the fight to us. We are in it. No matter what our ideas might have been towards the administration in the first place we are all behind the administration to-day with the last dollar, if it is necessary to expend it, for this country; and not only that, but with the last drop of blood in the veins of every American citizen. It will all go cheerfully for the cause which we believe is right if the demand is made of us.

Now, what is there to do? It seems to me that to-day there is a new slogan, "America for Americans and humanity." By that I mean we must produce as largely as possible, and use what we need here at home in a moderate and reasonable quantity, and we must send the rest abroad for the relief of those who are fighting for our cause. (Applause.)

As we go about the country there are at every railway crossing signs which have been very impressive to me: "Stop, look, and listen." I would like to paraphrase that sign for your consideration for the future: "Stop, visualize, and determine." Realize, not only for the present, but visualize for the future. What's going to take place? What is the situation we are going to face one of these days when there will be a change from war to peace? When peace comes our duty will have been only half done. Then will come the question of what will be our duty to those foreign lands—devastated, as they will be, suffering for want of provisions, suffering for everything—with no place to turn for the re-habilitation of those things except to this great country. Then comes the question how best can we serve that situation; then will come the time for us to exercise the best judgment, the wisest thought and the best efforts of the best minds in this country in the proper adjudication of what we propose for the relief of that situation. It is not too soon to be thinking along that line. Much could be said about that. There will be nations better able to pay than others; nations that can give to us probably twice as much as other nations for our product, giving us, therefore, the

opportunity to make twice as much money. We must consider that; we must analyze it; we must be just; we must try, as best we can, to have our relief fair and equitable all around, so that the whole devastated world may bloom and blossom, as nearly as possible, all at once, and come out of its turmoil and trouble. If, when peace comes, we can do our duty along the proper lines, there will come to us the greatest blessing that can come to any nation; and our reward will be the grateful expression of thanks to generous America, coupled with the hope that our nation may never pass from the face of the earth.

President Gary: The program is finished. It is twelve o'clock. What is your pleasure?

Voices: Schwab! Schwab!

President Gary: Mr. Schwab, you hear the call! You never fail us!

Mr. Chas. M. Schwab: Boys, at this late hour and under the circumstances, it is hardly fair to call upon me a second time to-day.

A short time ago up at Bethlehem, I was invited to make a little address at the opening of the Blind Institute. Well, I didn't know much what to say upon such an occasion, so I asked the Secretary of the Institution if he wouldn't prepare some data for me that I might use. So, with a great deal of care he prepared some statistics. I took down my encyclopedia and I looked up a lot of things pertaining to the blind, and about blind people who had been great in accomplishment, like Milton, and others who had lost their sight. And then I planned a pathetic appeal for the blind, and altogether I thought I had worked up a pretty good speech.

Well, the first man called happened to be the Secretary who had furnished me the statistics, and he used everything that he had prepared for me in that line. So that leg of my address suddenly vanished. But I felt that I was pretty strong on the pathetic side and had that to fall back upon, when the Bishop of that community was called upon to speak and he made the most pathetic speech you ever heard.

(Laughter.) I thought to myself, "Well, I have still got Milton and the other fellows to fall back upon," but the President of the Institution took as his theme the wonderful accomplishments of those who had lost their sight, and he knocked the last leg of my speech from under me, leaving me absolutely nothing of what I had so carefully prepared to say. So there was nothing else left for me to do but to compliment the officers of the Institution and the community! (Laughter.)

So, it seems to me that there is nothing much left for me here this evening, after all these splendid and learned and patriotic speeches that we have heard, but to compliment this Institution and its officers, and to compliment the City of Cincinnati and its people, and to express our appreciation of their hospitality, and to say how pleased we from the East are, to learn of their great success in the Liberty Loan. Cincinnati is very nearly equal to Bethlehem in that respect, and I want to tell you that when any city comes along and does what the people of Bethlehem have done,—well, they are doing pretty well, I will say that! (Applause.)

One thing of a serious character that struck me, referring now to the note of patriotism that has gone about this evening, is the seriousness of this great conflict we are in. I wonder how fully we realize what is before us? I always sound an optimistic note; I don't want to sound a pessimistic note. But don't let's go away from here with the idea that we are not facing the greatest task of our lives. Let's regard it with the seriousness that the situation deserves, and act accordingly. Let's not only talk patriotically but let's act patriotically. The soldier does not become a soldier simply because he has been drafted to serve as a soldier. He needs training; he needs many things before he becomes a soldier. Lord Kitchener said, "This is a war of machines; not a war of men." It takes men trained in the handling of machines to be successful in this war, and that training takes time, not only to get the machines but to train the men. I heard a story illustrating that about a Jewish friend who had been drafted into the army, and who was posted as a sentinel. One night, he heard a rustling noise, and he said, "Who

comes there?" "Friend." "Well," he said, "friend, advance and give the discount!" (Laughter.)

When I heard the stupendous figures about the revenues of the Government given by our distinguished citizen of Cincinnati, figures that staggered even my imagination, I kept thinking to myself all the time what a glorious place that would be to borrow money! (Laughter.) Some of you men said to me to-day, after I had finished my short address, "Oh! I don't think you are hard up; I don't think you owe much money." Boys, that's a mistake. One time a fellow came to me and wanted me to buy some securities, and he said, "Now, you can't lose anything." That reminded me of our great band up at Bethlehem, a splendid band, of one hundred and twenty people, I took them down to New York to play, as usual. After the concert I took them to Sherry's and gave them a good dinner. In that band there was a great big Pennsylvania Dutchman who played the bass drum, and he got to feeling pretty well. The dinner was good and the drinks were good, he belonged to a good band, he lived in a good community, he was employed in a good works, and he had had a good time, and he was in a good humor. When they got ready to go home, it was pretty late at night. On the way he was sitting in a seat of the car, with his head bowed and his hands in his pockets, half asleep and dreaming happy dreams, when the conductor came around and said, "Your ticket, please." He felt in one pocket and then in another, and he searched around for that ticket, and finally the conductor took hold of his coat to help him find the ticket, and he said to the conductor, "Do you know, conductor, I believe I have lost that ticket." "Oh! no," said the conductor, "you couldn't lose your ticket." "The hell I couldn't; I lost my bass drum to-day!" (Laughter.) If I keep on losing, and borrowing money to pay my losses, and then keep on subscribing to Liberty Loans, and borrowing the money to do that, well, I will just simply have to go to the United States Treasury! (Laughter.)

When Mr. Longworth was talking about all those "billions" I was reminded of the story of the two tramps who

were playing poker with grains of corn for chips. One of them said to the other, "I will raise you a thousand." The other one said, "I will raise you a million." Quick as a flash came the response, "I will raise you a billion." "Oh!" was the reply, "take the pot, you educated son-of-a-gun; I don't know what a billion is!" (Laughter.)

Boys, we have had a happy day; we have had a happy meeting; we have a happy and a jolly crowd of people. There is no event in my busy business life that I look forward to more than these meetings. I don't have much in my business life that is so cheerful and so delightful as the meetings of the old Iron and Steel crowd, with whom I have so long associated and whom I love so much. You are a jolly crowd of fellows. You are a crowd of fellows of whom every man is proud to say, "You are my friends." And when I receive your hearty hand grasp and your look of welcome and appreciation, after the years of friendship gone by, well, I am a happier man than any of you can ever hope to be on these occasions. Long may we meet to enjoy them; and may the results, first of all to our country be lasting and beneficial, and to ourselves personally always be as pleasant as they have been in the years gone by. (Applause.)

President Gary: Mr. Schwab said to-day he had on his books six hundred and ninety millions of accounts for material furnished to the government of the United States, and I have no doubt he will be going to Washington to visit the Treasury! (Laughter.) What is your further pleasure?

Voices: Butler! Butler!

President Gary: Uncle Joe, you're called for!

Mr. Joseph G. Butler, Jr.: Mr. President and Gentlemen: Being called for at this time of the night reminds me of the husband whose wife was taken suddenly ill, and who telephoned for the doctor. He said, "Doctor, hurry over; my wife is at death's door; come over and help pull her through!" (Laughter.) They have called upon me to help wind up this evening, because they know that I am proud of being here, and I am proud to face such a splendid, fine-looking lot of men—incidentally the ladies. (Laughter.)

After having paid my respects to Champ Clark this morning, and his very prompt disavowal, which came in about fifteen minutes after I got through speaking, I am going to pay my respects for just a brief moment to another gentleman that I have quite a disrespect for, Senator LaFollette. I happened to be appointed by the Youngstown Chamber of Commerce and by the Youngstown Steel Company and by the Brier Hill Steel Company and all the other organizations in Youngstown that I have anything to do with, as a delegate to the annual meeting of the Chamber of Commerce of the United States, which convened in Atlantic City some two or three weeks ago. I couldn't see that the delegates had very much to do with it; it was all cut and dried and all fixed up. But among other things offered to be taken into consideration by that body was a resolution prepared by the Chamber of Commerce of Green Bay, Wisconsin, LaFollette's state. The President of that Chamber got up and offered the resolution, which was referred to the Committee on Resolutions, that Senator LaFollette should be expelled from the United States Senate! There had been various other resolutions offered, but that one was received with profound satisfaction. Everybody there, apparently, was in accord with it, and I can't tell you how long the applause lasted when that gentleman proposed it. Along towards the close of the meeting, when all this cut-and-dried program had been threshed out—and as a matter of fact, a motion had been made to adjourn, but fortunately for me, it had not been seconded—they reported all these resolutions of one kind and another and hadn't said a word about this resolution on the subject of expelling Senator LaFollette. I rose to my feet and addressed the chair, and said, "I rise to make an inquiry: What has become of that resolution which was offered here by the President of the Chamber of Commerce, the resolution from Green Bay, Wisconsin, demanding that Senator LaFollette should be expelled from the United States Senate." The President of the Association said, "Why, the President of the Chamber of Commerce of Green Bay, Wisconsin, withdrew that resolution." "Well," I said, "that's a mistake,

and I am not satisfied with it. I want to tell you, gentlemen, that I date back to the Civil War—well, I might say to the Mexican War—and during the Civil War we had one Clement L. Vallandingham, of Ohio—I am sorry to say he was from Ohio, but damn it! he was born there—and I want to tell you what they did with him. His case was brought first before Governor Todd and then referred to President Lincoln, and President Lincoln sent him South. This man LaFollette should be sent to Germany; that's where he belongs." Well, you know I thought I had done something. There were a lot of reporters there and of course I thought that what I had said was going to be spread broadcast all over the United States. Yet here I am, the first one to proclaim publicly that LaFollette is a traitor to his country and ought to be stood up against a stone wall and shot. That's the way I felt about it. But I want to tell you that not one single word of all that was permitted to get into the newspapers. The Chairman, or somebody in authority, told all those reporters not to say a word about it but simply to let it go, and they did. There wasn't a word in the papers about it. About three or four days after that, Colonel Roosevelt, for whom I have a great affection and respect, took the subject up, and the newspapers were just full of it. You know, I have an idea that somebody in that audience communicated privately with Colonel Roosevelt and told him what I had said. If you will read the record in all the newspapers of the country you will find that the very arguments that I advanced before that body in Atlantic City were the arguments that the Colonel used. That's all I have to say on that subject.

This has been a patriotic gathering, inspired so by the condition of the country and what is going on in the world. The morning session was one of the most momentous things that ever I took any part in, and it was all impromptu. You will remember that once Judge Gary asked if we thought we were wasting time. Nobody thought that a minute was wasted.

Speaking of the labor question, I will tell you just a little incident that happened, and then I will retire. You know

the labor question is a very serious one. I am building a little building across from my residence, and it is my custom to go over there every morning and see how things are going on. I went over the other morning, and just as I arrived, a great big strapping colored man came up to the foreman. The foreman needed help and he said to the colored man, "Good morning, do you want to go to work?" "No," answered the colored man. "Why not?" "Well, I worked yesterday!" (Laughter.)

VOICES: Farrell! Farrell!

PRESIDENT GARY: We'd all like to hear a few words from you, Mr. Farrell.

MR. JAMES A. FARRELL: Mr. President, Ladies and Gentlemen: My remarks will be very brief. I was in the "selective draft" this morning, and because of that supposed that I was immune. But perhaps I ought to add a word or two.

We have had a very successful meeting; I think the best meeting of the American Iron and Steel Institute since our first meeting. On behalf of the Committee on Program I desire to thank those members who have read papers today, as well as those members who have discussed the most excellent papers read. I want to especially thank the Cincinnati Committee, of which Mr. James I. Stephenson is chairman. The arrangements have been most admirable and we have had a very good time here, so that I wish to express our special thanks and appreciation to that Committee. I wish to express our thanks also to the people of Cincinnati for their generous hospitality and to say to them that we will carry away from here in our hearts a feeling for this community which it will take a very long time to efface.

VOICES: Early! Early!

PRESIDENT GARY: Mr. George P. Early is called for to pronounce the benediction.

MR. GEORGE P. EARLY: Mr. President, Ladies and Gentlemen: I will detain you for only a few minutes.

There is nothing that gives so much concern to the American citizen at this time, as the welfare of his country. Our country is now engaged in the greatest crisis of our national existence. Without any justification whatever, the very life of our Republic and the liberty of our people have been attacked and are now in peril from the most powerful and the most merciless military organization the world has ever known. No criminal ever perpetrated the crime of murder with cooler deliberation, or with more vicious brutality, or with fiercer malice, than Germany has set out to murder the democracy of the world.

President Wilson, realizing the horrors of war, did everything he could consistent with national honor, and even suffered national humiliation, in order to keep us out of the war; but Germany has wantonly and wickedly forced war upon us, by killing our citizens, by sinking our ships, by insulting our flag, and by the most arrogant disregard of our most sacred rights.

No country ever entered upon war with a more righteous cause than that of our country. No matter where our sympathies may have been before the war, no matter what our opinion may have been in regard to our entry into the war, the fact is that we are now at war, and the time for discussion is closed. It is the duty of every loyal American citizen to give his unqualified support to our Government, and any man who fails to do that, to the fullest extent, is a traitor to his country! (Applause.) The condition must be utterly destroyed which made it possible for a few hundred men to set thirty-eight millions of men to slaughtering one another, and to inflict upon their families, their friends and their relatives, the ghastly misery and the crushing sorrows that will be remembered for years by aching hearts and tearful eyes.

This Republic was founded upon the triumph of the great principles of justice and political liberty. Those principles are so endeared to the American people that they will sacrifice every drop of blood and every dollar of treasure in support and in defense of them. From the foundation of the Republic the American flag has ever been the beacon

light of hope for the downtrodden and the distressed of many climes, and more people have sought our hospitable shores from Germany than from any other country in Europe, not only that they might escape the monster of militarism but that they might enjoy the inspiring liberty of our country and the splendid opportunities of American citizenship.

As the love of the flag of one's country is the noblest passion of the human heart, so treason to that flag is the most ignominious and damnable crime. The American flag has been borne across the Atlantic; the valor of our boys will emblazon victory upon its folds; and when the blessed day of peace shall come, it will again be the emblem of the brotherhood of man throughout the world, as well as the unrelenting foe of tyrannical rule.

The death knell of autocratic government is now sounding in Germany; the civilians are hearing it, and in a short time it will be heard upon the battle fields. Out of the sorrow and pain and travail and suffering of this cruel war, there will be born a new democracy throughout the world, which, we hope, will bring peace and good will upon earth, to all men, of all time. (Applause.)

President Gary: The meeting now stands adjourned. Good night!

PARTICIPANTS—MAY MEETING

(* Guests)

Abbott, F. E.
Abbott, W. H.
Acker, E. O'Connor
Adams, Charles E.
*Adams, F.
Ahles, R. L.
Akin, Thomas R.
Alder, T. P.
Alderdice, G. F.
*Alford, W. J.
Allen, John N.
Allen, J. P.
Alley, James C.
*Ames, E. W.
Anderson, Brooke
*Anderson, C. A., Jr.
Anderson, Nils
Andrews, J. I.
Armstrong, Eliot
Armstrong, V. C.
Atwater, C. G.
*Avery, Sewell L.

Baackes, Frank
Baackes, G. D.
Bacon, C. J.
Bailey, Edward
Bailey, George T.
Bailey, Wm. M.
Baily, T. F.
Baird, Frank B.
*Baker, E. D.
Baldridge, W. H.
Baldwin, H. G.
Baldwin, Lewis S.
*Baldwin, LeRoy W.
*Ballard, H. F.
*Balliatt, B. J.
Balsinger, W. R.
*Barber, E. J.
*Barbour, Geo. H.
Barbour, H. H.
*Barr, C. D.
*Barnes, Jas. R.
Barnhurst, H. G.
Barrows, W. A., Jr.
*Bateman, J. G.
*Baylies, F. N.
Beale, A. H.
Beale, Harry S.
*Bean, Henry Willard
Beaumont, George H.
Bebb, R. E.
Becker, Joseph
Beecher, L. T.
Bell, John E.
Benner, S. A.
Bennett, C. W.
Bergquist, J. G.
Biggert, Cassius F.
Biggert, F. C.
*Bird, J. P.
Birney, E. H.
*Bissell, John Bennett
Black, Herbert F.
*Blaine, S. Smith
Blanchard, C. M.
*Blandy, E. B.
*Bleecker, Warren F.
Block, L. E.
*Blowers, W. B.
Bonner, J. B.
Bope, H. P.
Booth, Charles M.
*Booth, Thomas T.
Bourne, H. K.
Boutwell, Roland H.
*Bower, W. C.
Bowler, R. P.
Bowman, Franklin M.
Boynton, A. J.
Bradley, John C.
Brainard, J. W.
Braine, L. F.
Breeden, William
*Broden, Albert
Brooks, Clyde
Brooks, J. J., Jr.
Brown, Fayette
*Brubaker, H. E.
Buck, C. A.
Budd, R. B.
Buffington, E. J.
*Bulkley, H. D.
Burden, I. Townsend
Burden, James A.
Burdick, Julian
Burdick, W. P.
*Burke, Charles H.
*Burleigh, Clarence
Burns, T.
*Burr, F. A.
Burry, James
Burt, D. A.
Bush, D. Fairfax
Bush, Harry D.
Butler, Gilbert
Butler, Joseph G., Jr.
*Byers, W. L.

Camp, J. M.
Campbell, J. A.
Carhart, P. E.
*Carminski, M.
Carnahan, R. B., Jr.
Carney, Frank D.
*Carpenter, C. H.
*Carpenter, L. G. W.
*Carpenter, W. P. C.
*Carrier, S. C.
*Carroll, A. W.
Carse, David B.
Carse, John B.
*Castyglone, F. S.
*Chapman, R. D.
Childs, William H.
*Chapin, A. H.
Christ, E. W.
Christian, A. W.
*Chrystie, Percival
*Church, E. S.
*Clack, C. T.
Clarke, A. Fielder
*Clarke, Chas. S.
Clarke, E. A. S.

Clemson, D. M.
Clopper, H. G.
Cluff, Charles C.
Clyde, W. G.
Coakley, J. A.
Coffin, W. C.
*Cohen, Fred W.
*Cohen, H.
Coles, T. B.
Collins, A. F.
Collins, C. A.
Collord, George L.
*Comstedt, J. F. A.
*Comstock, L. K.
*Cone, John J.
*Connean, A. M., Jr.
Connell, Frederick
*Cook, Howard H.
Cooper, S. G.
Corbett, W. T.
Corey, A. A.
Cornelius, Henry R.
Coulby, H.
*Coursen, W. C.
*Cowley, C. O. C.
*Cowling, J. V.
Cox, John Lyman
*Coxe, William G.
Crabtree, Fred
*Craig, T. H.
*Craig, W. W.
Crane, Theron I.
Crawford, E. R.
Crawford, George G.
Crawford, W. D.
Crispin, M. Jackson
Crocker, Geo. A., Jr.
Croft, H. W.
Cromwell, J. C.
Crook, Alfred
*Crotty, M. J.
Croxton, D. T.
Croxton, S. W.
*Curtis, T. H.

Daft, Andrew C.
*Dalton, H. A.
Dalton, H. G.
Damerel, George
Danforth, A. E.
*Darlington, Thomas
*Davaux, E.
Davey, W. H.
*Davidson, P. J.
Davies, George C.
Davis, A. L.
Davis, Charles C.
*Davis, D. S.
Davis, S. A.
Deericks, Joseph G.
*Delano, S. S.
Deming, Fred C.
Demory, A. W.
*Desmond, John F.
Dette, William
Deutsch, Samuel
Devens, H. F.
Devens, Richard
*Dickey, W. C.
Dilks, Lorenzo C.
Dillon, A. H.
Dillon, P. W.
*Dinkelspiel, J. L.
Dinkey, A. C.
Dinkey, Charles E.
*Dixon, E. M.
Dodd, A. W.
*Donnelly, W. T.
*Donner, Joseph W.
Donner, Robert
Donner, W. H.
*Donovan, Wm. F.
*Dorman, P. O.
*Dowden, A. G.
*Dow, Alex
Downs, G. F.
Drake, Fred R.
*Dreystool, N. V.
Driscoll, Daniel J.
*Drummond, R. S.
Duncan, John
Duncan, M. M.
Dyer, Philip S.
*Dyerle, O. M.

*Earnshaw, E. H.
*Earp, C. H.
Eaton, C. D.
Edwards, J. H.
Edwards, V. E.
*Edwards, W. M.
Ehles, Edward H.
*Embury, P. R., Col.
Endicott, George
*Eurdsley, H. S.
*Eustis, Harold E.
*Evans, J. Reid
Eynon, D. L.

*Fagan, John J. P.
*Falla, Fernando
Farrell, J. A.
*Farrell, John J.
Farrell, W. H.
Fedder, W. P.
*Fickinger, Emil
Field, William A.
*Filley, M. L.
Findley, A. I.
*Fitch, W. H.
Fleming, Henry S.
*Fletcher, J. T.
Flintermann, R. F.
Floersheim, Berthold
*Foley, P. R.
*Foote, A. Giraud
Foote, George C.
*Foote, Gilbert F.
*Foote, Gilbert F., Jr.
*Forbes, B. C.
Forbes, William A.
*Force, C. W.
*Fort, William L.
*Foster, F. B.
Fowler, A. A.
Francis, Lewis W.
Fraser, J. S.
Freeman, S. S.
*French, S. S.
Freyn, H. J.
*Fry, R. M.
*Fuhrer, M.
Fuller, J. W.

*Gallagher, J. W.
Gardner, Kirtland C.
Gardner, William
*Gartley, W. H.
Gary, Elbert H.
Gathman, Emil

Gayley, James
George, Jerome R.
Gerry, Roland
Gessler, Theodore A.
*Glass, George
Glass, John
Gleason, W. P.
Glenn, Thomas K.
Goddard, J. N.
*Goethals, Geo. W., Gen'l
*Gomber, Wm.
*Gomez, Lucho C., Adm'l
*Goodrich, C. C.
Gordon, Frank H.
Gordon, Peter J.
Gould, Frank
*Grady, Charles B.
*Graff, E. D.
Graham, Chas. J.
*Graham, Robert E.
Grange, A. B.
*Grant, A. W.
Gray, J. H.
*Gray, Wm. G.
Greenawalt, John E.
*Greene, J. W.
Gresham, W. B.
Griffin, James C.
Griffiths, E. S.
Grose, J. H.
Groves, Edwin
Grugan, Justice
Gruss, William J.
Gulick, Henry

Hagar, Edward M.
*Hager, W. M.
Hale, Samuel
Hall, R. S.
Hamilton, E. J.
Hamilton, F. D.
Hammond, James H.
*Hancock, W. W.
*Hanlon, W. W.
Hanna, L. C., Jr.
*Hardenbergh, H.
*Hardy, A. B. C.
*Harrington, John T.
Harrison, Edwin H.
*Hart, C. H.
*Hastings, G. B.
Hatfield, Joshua A.z
*Hay, H. G.
Hayman, E. J.
*Hazen, Wm. E.
Heckscher, August
Heedy, H. Glenn
*Henry, E. A.
*Henry, A. S.
Henshaw, John O.
*Heppenheimer, Wm. C.
Heppenstall, C. W.
Herndon, E. L.
*Herr, D. D.
Herrmann, Chas. E.
Hewitt, Erskine
Hickox, Wilson B.
*Higgins, J. W.
Higgins, W. B.
*Higinbotham, N. J.
Hilands, J. P.
Hildrup, William T., Jr.
*Hilliard, W. H. R.
Hillman, J. H.
*Hite, George W.
Hobson, Robert
Hoerle, F. D.
*Hoffman, W. L.
Holbrook, Percy
Holding, James C. C.
Holliday, J. S.
Holloway, W. W.
*Holmes, C. O.
*Holzworth, C. R.
*Hopkins, W. R.
Horner, W. S.
*Houston, George H.
Howard, Clarence H.
Howe, Henry M.
Howell, Alfred C.
Howell, H. P.
Howland, H. P.
*Howland, S. W.
*Howland, W. I., Jr.
*Hoyt, Colgate
Hubbard, P. H.
*Hughes, E. P.
Hughes, H. L.
Hughes, I. Lamont
Hughes, John
Hughes, William H.
*Hulick, William H.
Hulst, John
*Hunt, I. M.
Hunter, J. A.
*Huntley, F. P.
Hurd, Herman M.
Hurlbert, William G.
Huston, A. F.
Hutchinson, O. N.
*Huxley, Henry M.
Hyatt, W. E.

*Igoe, Andrew
*Igoe, Peter
Irons, Robert H.
Irvin, William A.
Isham, Phillips
Ives, E. L.

*Jacobus, David S.
James, Henry L.
*Jamieson, Charles C.
Jay, John C., Jr.
*Jayne, Chester A.
*Jayne, D. W.
*Jennings, W. H.
*Johnson, F. E., Jr.
Johnson, Frank H.
Johnson, J. E., Jr.
Johnston, A.
Johnston, C. T.
Jones, E. F.
Jones, H. L.
Jones, Harry R.
Jones, J. M.
Jones, James C.
Jones, John E.
Jones, Jonathan R.
Jones, Richard, Jr.
*Juve, Gabriel

*Kafka, Frank
*Kafka, Otto
Kauffman, Walter L.
Kaufholz, G. F.
Keefe, J. S.
*Keeney, R. N.
Kellogg, M. W.
*Kelly, F. A.

Kennedy, Frank G.
Kennedy, Hugh
Kennedy, J. J.
Kennedy, Thomas W.
Kenney, E. F.
Kent, J. F.
Ker, Severn P.
Kerr, D. G.
*Kerr, D. W.
*Kiernan, Paul L.
*Kilner, R. H.
Kimball, G. C.
*King, John M.
King, W. L.
*Kister, F. F.
*Klein, L. C.
*Knecht, Marcel
Kneeland, Edward
Knowles, A. S.
Knox, Luther L.
Kranz, W. G.
*Kreutzberg, E. C.
Kreps, J. E.
*Krick, C. S.
*Krieg, Chas. W.
*Kuker, S.

Lamont, Robert P.
Lanahan, Frank J.
*Langdon, A. W.
Larkin, J. K.
*Lathrop, A. P.
*Lauzanne, Stephane
Lavelle, T. M.
Lavino, Edward J.
Lea, Robert C.
*Leehey, M. D.
Lee, Leif
Leech, Malcolm W.
Leet, George K.
*Lefter, F.
Lehman, Albert C.
Lemoine, L. R.
Lenhart, C. E.
Le Van, G. B.
*Lewellyn, D. E.
*Lewis, F. H.
Lewis, J. E.
Lewis, W. H.
*Lidell, Donald

*Lilly, Joseph T.
Lippincott, James
Lockhart, Henry, Jr.
Logan, John W.
*Loughman, W. E.
*Long, J. H.
Lozier, Chas. E.
Lukens, W. W.
Lustenberger, L. C.
*Lynch, Edmund C.
*Lynch, Warren J.

*MacArthur, D.
MacDonald, D. C.
MacDonald, R. A.
*MacMill, Charles
McAlarney, J. H.
McAteer, H. W.
*McCaffrey, Thomas
*McCarter, Thomas N.
McCauley, J. E.
McCleary, Elmer T.
*McCleary, James T.
McConnell, John
McConnell, Malcolm F.
McDougall, D. H.
McDonald, Thomas
McElhany, C. B.
McIntyre, W. W.
McIlvain, Edward M.
McIlravy, W. N.
McKelvy, E. A .
McLauchlan, Jay C.
McLeod, John
Maeder, Carl
Manning, William E.
Marchant, Clarence R.
*Mark, Clarence
Marseilles, W. P.
Marshall, C. D.
Marshall, C. S.
*Marshall, D. J.
Marshall, S. M.
Mather, Amasa Stone
Mather, Samuel
Mather, S. L.
Mather, William G.
Mathesius, Walther
Mathews, John A.
*Matthews, H. L..

*Mehlfeld, John E.
Mehlhorn, W. M.
Meissner, C. A.
*Melville, H. H.
Mercur, Robert J.
Merriam, I. B., Jr.
Mesta, George
Meyers, F.
*Michel, Raymond
*Middleton, Merle
*Miller, C. D.
*Miller, George
*Miller, L. H.
Moeller, R. C.
Mogan, C. J.
Moore, H. G.
Moore, Philip W.
Morgan, W. H.
Morris, A. F.
Morris, L. B.
*Morris, W. Cullen
Morse, A. C.
*Morse, Frank L.
*Morse, Lewis Kennedy
Moss, John B.
Muchnic, Charles M.
Mudge, E. W.
Murray, Montgomery
Murray, Thomas
*Myers, W. J.

Nash, A. L.
*Neide, W. B.
*Nevin, John
*Nevins, Thomas A.
Newson, H. H.
Newton, P. A.
Nichols, J. A.
Niedringhaus, G. W.
*Nields, Benjamin, Jr.
Niemann, C. F.
*Nimmo, Mr.
*Norton, S. S.

O'Bleness, H. M.
*Ogden, J. C.
Ohl, Edwin N.
*O'Laughlin, L. J.
*Orbanowski, K. A.
*O'Reilly, Jos. B.

Orrok, George A.
Ortmann, Rudolph
*Owen, G. B.

*Page, Francis S.
Palmer, William P.
*Pardee, I. P.
Pargny, E. W.
*Parker, J. A.
*Parker, J. H.
*Paxton, A. B.
Peck, C. J.
Peckitt, Leonard
Pendleton, Joseph S.
Penton, John A.
Perkins, Frederick C.
Perkins, George W.
Perry, J. E.
Perry, John E.
Pessano, A. C.
Peters, E. V.
Peters, Richard
Petinot, N.
*Pfeiff, L.
Phillips, W. V.
Pierce, Edwin H.
Pilling, W. S.
Plummer, James
*Pond, C. P.
Poor, F. A.
Pope, Henry F.
*Pratt, H. A.
Pratt, R. H.
Prendergast, George A.
Prendergast, W. C.
Preston, Veryl
*Purnell, Arthur
Putnam, Chas. R.

*Queal, H. P.
Quincy, C. F.

Rachals, Walter
Rainey, Roy A.
Ramsburg, C. J.
*Ramsey, W. H.
Rand, Chas. F.
Randolph, R. F., Jr.
Rathbone, Richmond L.
Raymond, H. A.
Rees, J. A.
Reese, P. P.
Reeves, David
*Regula, Albert S.
*Reimer, H. C.
Reis, John
Replogle, J. Leonard
Reynders, John V. W.
*Rice, E. W., Jr.
Rice, R. H.
*Rider, J. B.
Riddle, L. E.
Ridgway, William H.
*Ripperger, W. F.
Roberts, F. C.
Roberts, W. F.
Robinson, C. R.
Robinson, C. S.
*Robinson, Dwight P.
Robinson, T. W.
*Roe, J. P.
*Rogers, Ira C.
Rogers, Weaver H.
Rose, George E.
Rowe, Wallace H.
Rumney, John G.
Runyon, W. C.
Runyon, W. C., Jr.
Rushmore, David B.
Russell, N. F. S.
*Rust, A. T. M.
Rust, E. G.
Rust, E. M.
Rust, H. B.
Rust, S. M.
Rust, W. F.
*Ryan, Allen A.
Ryan, D. J.
Ryan, F. J.
Ryerson, Donald M.
Ryerson, Joseph T.
Rys, C. F. W.

Sagendorph, S. A.
Samuel, Frank
Savage, H. D.
Savage, Joseph F.
Sawhill, E. P.
*Sawyer, H. N.
*Scammell, M. J.
Schiller, Wm. B.
Schleiter, Walter F.
*Schlendorf, J. M.
*Schmid, Marten
Schnatz, G. T.
*Schneider, A. A.
Schuler, J. H.
*Schultz, L. C.
Scott, G. C.
Scott, G. E.
Shepard, W. T.
Sherer, Norman
Sherman, Wm. O'Neill
Sherwin, John
*Sholl, E. P.
Short, G. W.
*Shotwell, Thomas E.
Shover, Barton R.
Sias, John M.
Siebert, W. P.
*Siebert, W. P., Jr.
Simpers, Thos. W.
Singmaster, J. A.
Sinn, Francis P.
Slick, E. E.
*Sloan, A. P., Jr.
*Sloane, Parker
Smart, George
*Smith, B. S.
Smith, Floyd K.
*Smith, Frank K.
*Smith, J. C.
Smith, James W.
*Smith, Pemberton
Smith, S. L.
*Snodgrass, John H.
Snyder, William P.
Speller, F. N.
*Spencer, F. N.
*Spilsbury, E. G.
*Spilsbury, H. G.
*Sprague, D. J.
*Squire, Andrew
*Staehle, Alfred M.
Stambaugh, John
*Stanford, G. I.
*Stapleton, L. D.
*Stark, C. J.
Stebbins, H. S.
*Steif, E. A.

Steinen, Fred W.
Stephenson, James I.
Stevens, Chas. G.
*Stevens, C. N.
Stevens, H. L.
Stevenson, A. A.
*Stevenson, Barton
Stewart, Hamilton
Stewart, Scott
Stillman, Chas. A.
Stillman, J. S.
Stoddard, H. G.
Stoughton, Bradley
*Stout, A. P., Dr.
Stratton, W. H.
*Strong, W. E. S.
*Stuart, C. E.
*Sturtevant, Paul
Sullivan, G. M.
*Sullivan, George R.
Sullivan, W. J.
*Summers, Linder T.
Swartz, A. H.
*Sweet, W. A.
Sykes, W.
*Symons, F. E.

*Tackaberry, F. H.
Tallcott, Daniel W.
Tallcott, Daniel W., Jr.
Taylor, Knox
Taylor, T. H.
Taylor, Wade A.
*Terbell, J. B.
Thomas, Albert J.
*Thomas, C. E.
*Thomas, David
Thomas, E. P.
*Thomas, Isaac B.
Thomas, T. E.
Thompson, Andrew
Thompson, A. W.
*Thompson, Edward D.
*Thompson, Lynn W.
*Tickner, F. W.
Tod, Fred
Todd, William B.
*Tomlinson, Sile L.
*Tonnele, Theodore
Topping, John A.
*Towne, Joseph M.
Towne, Thomas
Trabold, Frank W.
Tracy, D. E.
Tripp, Chester D.
Trumbull, Frank
Tutein, E. Arthur
*Tyshnoff, V.

*Underwood, C. E.
Unger, J. S.

Valentine, Stirling G.
*Van Ackeren, J.
*Vanderbeck, S. R.
*Van Tress, H. L.
*Veeder, Mr.
*Vincent, Frank H.
Vogt, A. W.
Vogt, F. A.
Von Baur, C. H.
*Vought, C. S.
Vreeland, George W.

Waddell, Jacob D.
Wadsworth, J. E.
*Waldron, J. G.
Walker, W. R.
*Walling, A. S.
Wallingford, B. A., Jr.
Ward, David L.
Warren, W. H.
Waterhouse, George B.
*Watson, Geo. T.
*Watson, J. O.
*Watson, Robert W.
*Watson, Wm. A.
Watson, W. E.
Wayland-Smith, R.
Webb, Albert R.
Webster, W. R.
Weir, Ernest T.
Weir, D. M.
Weiss, Jay G.
Welch, William W.
*Wellington, F. E.
Wellman, S. T.
*Wells, George M.
Wendell, Carl
Westfall, H. D.
*Whaley, A. R.
*Wheeler, C. P.
*Wheeler, F. S.
Wheeler, Seymour
*Whitcomb, H. D.
Whitney, H. LeRoy
*Whitney, R. H.
Whittemore, E. L.
Wickwire, W. A.
*Wickwire, W. A., Jr.
*Wight, S. B.
Wiley, Brent
*Wilkins, J. F.
Wilkinson, Horace S.
*Willard, L. L.
*Williams, Elmer R.
*Williams, J. H.
*Williams, L. D.
Wilputte, Louis
*Wilson, Horace N.
Wilson, Willard
Wolfe, W. L.
*Wolhaupter, Benj.
Wood, Charles L.
Wood, F. W.
Wood, Leonard G.
Wood, Richard G.
Wood, Walter
Woods, John E.
Woodward, A. H.
Woolsey, A. E.
*Wortham, Milford
Wright, S. D.
Wysor, R. J.

*Yates, Harry
Young, A. G.
Young, A. H.

Zehnder, C. H.
Zehnder, E. M.
*Zimmerman, A. E.

PARTICIPANTS—OCTOBER MEETING

(* Guests)

Abbott, W. H.
Abell, O. J.
*Adams, J. L.
Affelder, Louis J.
Affleck, B. F.
*Agnew, J. D.
*Ahlbrandt, G. F.
Akin, Thos. R.
Alderdice, G. F.
Allen, John N.
*Allen, T. G.
*Alter, R. S.
*Amole, E. B.
Anderson, Brooke
Anderson, Nils
Andresen, H. A.
*Andrews, A. K.
*Andrews, A. L.
*Andrews, Frank M.
Andrews, Jos. B.
*Andrews, Jos. G.
Andrews, Wm. N.
*Appleton, A. I.
Armstrong, Eliot
Assmann, F. A.
Atcherson, R. W. H.
*Au Werter, J. T.

Baackes, Frank
Backert, A. O.
Bailey, Geo. T.
Bailey, Richard W.
Baily, T. F.
Baird, D. B.
Baker, E. D.
*Baker, H. L.
Baldwin, H. G.
Baldwin, R. L.
Balkwell, Geo. W.
Ball, W. H.
*Ballard, J. A.
*Ballman, Frank
*Bardes, E. H.
*Barnes, George K.
*Barnitz, W. O.
Barren, H. A.
Barren, H. B.
*Bartlit, R. H.
Battelle, J. G.
Bauer, H. E.
Beale, A. H.
Beaumont, George H.
*Beck, W. J.
Beecher, L. T.
Beegle, F. N.
Bennett, C. W.
Bennett, William H.
Bentley, F. T.
*Berger, E. F.
*Bigger, C. M.
Biggert, C. F.
Bigler, Frank S.
Billings, Frank
Billingslea, E. L.
Birney, E. H.
Black, E. S.
*Blaxter, H. V.
*Bliss, Walter
Block, L. E.
*Bole, H. B.
Boley, Ernst
Booth, Lloyd
*Botts, F. A.
*Boughton, A. C.
Bourne, B. F.
Bourne, H. K.
*Bradley, J. H.
*Brett, J. A.
*Briscoe, J. H.
*Brister, C. J.
Brooks, Clyde
Brown, Alexander C.
Brown, Charles M.
*Brown, J. F.
*Brown, Dr.
Brubaker, H. E.
*Brubaker, Jas.
*Bryant, H. C.
Buck, D. M.
Buffington, E. J.
*Bull, R. A.
Burdick, W. P.
Busch, Harry C.
Bush, D. Fairfax
Butler, Gilbert
Butler, J. G., Jr.

Caldwell, C. D.
Campbell, J. A.
Campbell, L. J., Major
Campbell, R. W.
Carhart, P. E.
Carnahan, R. B., Jr.
Carruthers, J. G.
*Carruthers, T. H.
Cartwright, J. H.
*Carver, W. W.
*Champion, A. Burt
Chandler, J. C.
Charls, George H.
Chisholm, A. S.
*Clark, Geo. A.
*Clark, Geo. M.
Clarke, E. A. S.
Cluff, Chas. C.
Coffin, W. C.
Collier, W. E.
Collord, N. W.
Cook, Edward B.
Cook, Harry H.
*Cook, Howard H.
Cooper, S. G.
Cordes, Frank
Cornelius, Henry R.
Cowling, J. V.
Crabtree, Fred
Crawford, E. R.
Crockard, Frank H.
Crook, Alfred

*Dahl, K., Jr.
Danford, M. E.
*Danforth, A. E.
Davis, A. L.
Davis, Henry J.

Davis, S. A.
Davis, W. W.
*Dansen, E. B.
Dean, Wm. T.
Deericks, J. G.
Deetrick, J. W.
Demory, Adam R.
Dempsey, James H.
*Denman, L. E.
Dette, William
Deutsch, Samuel
*Dickerson, A. V.
Dilks, Lorenzo C.
Dillon, A. H.
*Dimmick, H. V.
Dimmick, R. B.
*Domhoff, C. H.
Donner, W. H.
Dorman, A. D.
*Dorman, P. O.
Dougherty, J. W.
*Dowden, A. G.
Driscoll, Daniel J.
Duncan, John
Dunham, Lewis E.

Early, Geo. P.
*Eaton, W. G.
Edgar, S. C., Jr.
Edwards, J. H.
Eldridge, S. E.
Elliot, Thos.
Eppelsheimer, D.
Eschenbrenner, D. F.
Estep, H. Cole
Evans, David
Eynon, David Lloyd
Eynon, David L.

Farrell, James A.
Fletcher, Jno. F.
Fairbairn, C. T.
Fitch, W. H.
*Fitzwilson, C. H.
*Fleming, W. R.
Floersheim, B.
Follansbee, Wm. U.
Forbes, William A.
*Forrest, J. D.
*Foster, W. H.
Fowler, A. A.
Fraser, J. S.
French, Maynard
Freyn, H. J.
*Fuller, E. C.
Fuller, F. M.

Galvin, J. E.
Garry, A. H.
*Garvin, J. M.
Gary, Elbert H.
Geddes, Robert
*Geesman, Wm.
Gerry, Roland
*Gilfillan, S. G.
Girdler, T. M.
Glass, Alex.
Glass, John
Gleason, William P.
Glenn, Thos. K.
Goltra, E. F.
Gould, Frank
Graff, Everett D.
*Graham, R. H.
Grange, A. B.
Gray, J. H.
*Gregg, W. W.
Griswold, H. C.
*Green, James A.
Gruss, William J.

Hackett, S. E.
Hagar, E. M.
Hall, R. S.
Hamilton, Alex. K.
Hammond, James H.
Hanlon, W. W.
Hanna, L. C., Jr.
*Harding, J. G.
Harrison, N. C.
Hart, Charles
Hart, John M.
Haswell, J. C.
Hastings, R. W.
Hatfield, Joshua A.
Hayes, Will L.
*Hayman, E. J.
Hendricksen, J. J.
*Hettiger, E. P.
*Heyser, R. O.
Hickok, Charles N.
Hickman, Baylor
Higgins, H. E.
*Hildebrandt, C. A.
*Hite, George W.
*Hinsch, Charles A.
*Hitchcock, Reuben
Hobbs, C. H.
Hobson, Robert
*Hodson, Frank
Hoerr, Alex. L.
Hoff, J. J.
Holbrook, Percy
Holmes, G. C.
Hook, Arthur S.
Hook, Chas. R.
Horner, W. S.
Howard, Clarence H.
Howell, Alfred C.
*Howell, H. C.
Howell, H. P.
Howland, H. P.
Hoyt, Elton 2nd
Hubbard, P. H.
*Hudson, A. H.
Hudson, Banks
*Hudson, C. L.
*Huffman, O. H.
Hughes, William H.
Hull, D. D., Jr.
Hume, J. E. N.
Hunt, A. R.
Hunt, Robert W.
Hunter, H. M. L.
Hunter, John A.
*Huston, Joseph E.
*Huston, R. T.
Hutchinson, B. E.
Hutchinson, O. N.
Hurlbert, Wm. G.
Hutton, J. M.

Irons, Robert H.
*Irwin, Charles
Isham, P.
*Iseminger, J. M.

James, Henry L.
James, W. A.
*Jamieson, F. E.

*Jantz, G. H.
Jarecki, Alex
Jenks, Geo. S.
Jewell, T. M.
Jewell, William E.
Johnson, Frank H.
Johnston, C. T.
*Jones, Charles D.
Jones, Evan F.
Jones, Harold C.
*Jones, I. O.
Jones, James C.
Jones, John E.
*Jones, Lloyd
*Joseph, Arthur
*Joseph, David
Joseph, Eli
*Joseph, Maurice

Kagarise, John W.
Kauffman, W. L.
Kaufholz, C. F.
Kebler, Eliot A.
Keefe, J. S.
*Kennedy, Jas. B.
Kennedy, J. J.
Kennedy, T. W.
Ker, Severn P.
*Kilner, R. H.
Kimball, G. C.
*King, Robert A.
*Kinsey, Boyden
*Kittoe, G. H.
*Knapp, Herman M.
Knox, Luther L.
*Krieg, Charles
Kranz, W. G.
Kreitter, J. W.
Kreps, J. E.

Lacey, H. R.
Lambert, John
*Lamson, B. W.
Lanahan, Frank J.
Landgrebe, Karl
Langenbach, Edward
Larkin, J. K.
Laughlin, Alex.
*Lavine, Saul
*Lawson, Fenton
*Layne, J. C.
Lea, Robert C.
Leet, George K.
Lemoine, L. R.
*Lewis, Charles
*Lewis, Davis S.
Lewis, John F.
Lippincott, James
*Littleford, J. S.
*Littleford, Roger S.
*Littleford, Thomas
Llewellyn, F. J.
Llewellyn, John T.
Llewellyn, Silas J.
*Long, Geo. J.
*Longworth, Nicholas
*Lowry, J. B. F.
Lusk, R. W.
Lustenberger, L. C.
*Lyon, Dorsey A.

*McBride, Harry
*McCandless, H. W.
McCauley, John E.
*McCleary, James T.
McCloy, John H.
McConnell, John
McDonald, Louis N.
McDonald, Thos.
*McDonnell, E. J.
McFate, W. H.
*McGlaughlin, G. G.
McGowan, C. L.
McIlravy, W. N.
McKee, Arthur G.
*McKee, M. E.
McLauchlan, Wm. M.
McMahon, William C.
McMillen, A. K.
*McMurray, Max
Mackenzie, W. P.
Mann, Henry S.
Manning, William E.
Marchant, C. R.
*Marsh, W. R.
Marshall, C. S.
*Marshall, D. J.
Martin, C. W.
Martin, E. H.
*Martin, J. D.
Mather, A. S.
Mathews, John A.
Meacham, D. B.
Meissner, C. A.
*Mercer, L. D.
Merriam, Isaac B., Jr.
Merriman, D. A.
Michaels, Joseph
Miller, C. L.
*Miller, F. W.
*Miller, H. O.
Miller, J. C.
Mills, J. R.
*Moeschl, Frank A.
Moffett, C. A.
Moore, V. Mumford
*Morris, Frank E.
*Morris, George H.
Morse, A. C.
*Morten, J. D.
*Mueller, A. M.
*Muench, Lewis
*Mullen, Andrew
*Murphy, W. H.

*Newton, Edmund
Newton, J. B.
*Newton, O. B.
Newsom, H. H.
*Nicholas, R. C.
Nichols, J. A.
Niedringhaus, George W.
Niemann, C. F.
Nulsen, F. E.
Nutt, James H.

Ohl, Edwin N.
*Olden, H. L.
*Olfs, A. C.
*Orr, E. Delvin
*Ottis, F. J.
*Overholt, A. C.

*Pack, Albert
*Paoli, Elmo de
Pargny, E. W.
*Parmenter, W. L.
*Pasquali, Mario
*Pauly, K. A.

*Peebles, S. C.
*Peebles, John
Pendleton, H. N.
Penton, John A.
Perley, Ward B.
Petinot, N.
*Peters, E. M.
Peters, Richard, Jr.
Pflager, H. M.
*Phillips, M. Standish
Phillips, R. C.
Phillips, W. Vernon
Phipps, C. R.
*Pierce, E. C.
Pierce, Talbot E.
*Pollak, Julian
*Pollak, Morris
Pollock, Joseph K.
Pope, Henry F.
Porch, Jas. W.
*Porter, K. E.
*Powell, T. C.
*Prescott, E. J.
*Procter, Cooper
*Puckett, W. M.
Putnam, Louis R.

Quarrie, B. D.

*Radway, E. M.
Ralston, J. S.
*Ransom, W. S.
Rathbone, R. L.
Raymond, H. A.
Reese, P. P.
*Rectanus, S. R.
*Reilly, Edgar J.
Reilly, W. C.
Reynders, John V. W.
*Reynolds, R. D.
*Rice, W. C.
*Robertson, W. F.
*Robertson, W. L.
Robinson, C. R.
Robinson, C. S.
Robinson, T. W.
Rodgers, S. M.
Roesch, J. A., Jr.
Rogers, William A.
*Roney, J. L.
Rose, Geo. E.
*Rowe, Caspar
*Rowe, M. D.
*Rowe, W. S.
*Ruder, E. G.
Rumney, John G.
*Ryan, D. J.
Ryan, F. J.
Ryerson, Joseph T.

*Sackett, F. J.
*Sargent, John
Savage, John A.
Savage, Joseph F.
Sawhill, E. P.
*Scherer, Arthur
Schleiter, Walter F.
*Schmidlapp, J. G.
*Schroeder, W. J.
Schuler, J. H.
Schwab, Charles M.
Scott, Geo. C.
Seaton, W. B.
*Sebastiani, James A.
Selmi, L.
Shannon, W. T.
*Shaw, Roscoe T.
Sheldon, Samuel B.
Shepard, W. T.
*Shinkle, A. Clifford
Shimer, Geo. S.
Siebert, W. P.
*Simpson, F. H.
Singer, Arthur J.
Sivyer, F. L.
*Skiles, R. C.
*Slaback, L. K.
*Sloan, Chas. H.
*Sloane, Parker
Smart, George
Smith, C. C.
*Smith, Charles L.
Smith, Floyd K.
Smith, H. Sanborn
*Smith, J. C.
Smith, Samuel Lewis
Sommer, B. L.
Sparhawk, E. M.
Spilsbury, H. G.
*Sproull, E. T.
*Stacey, James E.
*Stark, C. J.
Stephenson, Bertram S.
Stephenson, James I.
*Stephenson, Samuel
Stephenson, S. E.
Stevens, Charles G.
Stevenson, M. R.
*Stevenson, W. C.
*Stevenson, W. E.
Stewart, Hamilton
Stillman, Chas. A.
Stone, Walter C.
*Strongman, J. H.
Sturtevant, Paul
*Sutphin, S. B.
Swartz, Alfred H.
Sweeney, M. J.
Sykes, W.

*Taft, Charles P.
*Talbott, C. R.
Taylor, T. H.
Tener, R. W.
*Tenner, W. A.
*Thomas, C. L.
Thomas, C. S.
Thomas, E. P.
Thomas, George, 3rd,
Thomas, Leon E.
Thomas, T. E.
Thomas, W. A.
Thompson, A. W.
*Thompson, H. L.
Thorp, Geo. G.
Tod, Fred
*Topp, Herbert F.
Touceda, Enrique
Townsend, H. E.
Trainer, W. B.
*Treadwell, M. H.
*Troutman, William E.
*Trust, S. W.
*Turner, R. T.
*Tytus, John B.

Unger, J. S.
Utley, S. W.

Van Schaick, Arthur P.
Verity, George M.
*Verity, C. W.

Wales, S. S.
Wallingford, B. A.
*Walter, L. F.
*Ward, C. S. B.
Ward, D. L.
Warren, Wm. H.
*Warner, G. P.
Waterhouse, G. B.
Weatherwax, H. B.
Webb, Francis J.
*Webb, Lewis M.
Wendell, Carl
Weston, W. B.
Wheeler, Seymour
*Whitaker, Samuel H.
White, G. A.
Whiting, John H.
Wiley, Brent
Wilkin, John T.
*Willcox, F. H.
Wille, Fred
*Williams, Day
Williams, H. D.
*Wilson, Horace N.
Wilson, P. F.
Wilson, Willard
*Woodmansee, D. D.
Woods, John E.
*Worcester, H. A.
Worton, S. G.
Wright, S. D.
Wright, Wm. H.
*Withenbury, R. N.
*Wyatt, C. A.

*York, L. Z.
Young, A. G.